PLANT EQUIPMENT PACKAGE MODERNIZATION PROGRAM

Volume 4-1

Model Lines

prepared for

Project Manager
Munitions Production Base Modernization and Expansion

administered by

Picatinny Arsenal

under Contract No. DAAA21-75-C-0303

April 1976

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18. SUPPLEMENTARY NOTES
The model lines were designed as standards for the use of the PEP Modernization Program teams to evaluate the producers' capabilities to meet mobilization requirements.

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*
Plant equipment package (PEP)
Modernization
Production line
Technical data package (TDP)
Operations analysis
Process description summary
Industrial plant equipment (IPE)
Other plant equipment (OPE)

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*
Model lines are theoretical munition production lines related to technical data package (TDP) configurations and specifications. They are standards consisting of brief technical information and defining production requirements of particular end items, with operations and process methods compatible with state-of-the-art munitions production technology.

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PLANT EQUIPMENT PACKAGE MODERNIZATION PROGRAM.

Volume 4-1.
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MODEL LINES:
Shell, HE, M483/M107-155MM
Case, Cartridge, M115B1, M148A1B1, M150B1-105MM
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SHELL, HE, M483 — 155 MM

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PLANT EQUIPMENT PACKAGE
MODERNIZATION PROGRAM

Volume 4-1
Report No. 75-86-R-4-1
MODEL LINE ~~DEVELOPMENT~~
SHELL, HE, M483/M107-155MM

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I. INTRODUCTION

A model line is a theoretical munitions production line, related directly to the technical data package configuration and specifications. It is not intended to be a complete or sized production line that could be established in the future to produce a specified quantity of end item(s).

The model line is a benchmark made up of brief, but precise, technical information defining the production requirements of the particular end item, with process methods compatible with the proven state of the art in munitions production technology.

The model line will be the standard used by the PEP modernization team to review, analyze, and assess the active and inactive producers' existing capabilities to meet mobilization requirements. The model line documentation will include alternative process methods and technologies for the purpose of analysis, evaluation, and implementation of the most appropriate manufacturing system. Some processes within the line that are listed as alternatives are capable of producing the original item only and may not meet the requirements for production of the replacement item. Again, these alternatives are included solely for a better evaluation of the current line.

The model line described in this report is designed to produce the following metal parts:

	M483	M107
Body	10542911-12	10535927
Ogive	10542916	N/A
Base	10542904	10535928

The remaining parts of the 155mm projectile are purchased from vendors specializing in the processes required to produce the particular part. For example, Part No. 1054290?, the obturator, is made from a plastic material and would be produced by a vendor having plastic molding capabilities. The large number of variables existing in current methods of producing the body, base, and ogive generated a problem when trying to present the one, most adequate model line. To overcome this difficulty, a composite, including each operation, was constructed. This composite line is the model line against which existing 155mm lines producing similar configurations will be evaluated.

The following sources of information were used in planning the model .ine.

1. Battelle Memorial Institute, "Engineering Survey and Analysis," dated 10 May 1959 pertaining to methods of manufacturing artillery shells.

2. Kaiser Engineers Report 75-15, "Equipment Study for 155MM, M483 Projectile Metal Parts Facility," dated March 1975, prepared for the U. S. Army Corps of Engineers.

3. The Army Ammunition Production Base Reconfiguration Study, Volume 14, "Manufacturing Facility for Metal Parts for 155MM Projectile M483," dated March 1974.

4. Base Production units: Shell, HE, M483, 155MM for Chamberlain Corp., Norris Industries, and X-facility (formerly Gulf & Western).

II. CHARACTERISTICS

Although the model line lists sequential operations, each operation may vary with respect to equipment used, completeness of operation performed, producer's labor skills, and the use of proprietary processes. The equipment may vary in that a mechanical press may be used instead of a hydraulic press, or a multispindle lathe may be used instead of an automatic, single-spindle lathe. Completeness of operation may vary because a producer may use single tooling and multiple presses instead of multiple tooling and a single press. Special processes used exclusively by a producer might combine sequential operations, etc.

Furnace capability is listed as a guide and may vary with producer processes, locale, and available energy source(s).

Machine tools are listed as to type rather than specific size or make. For example, a machine tool could be listed as a multispindle or automatic chucker to indicate the type.

Chemical lines are not detailed as to dips, washes, rinses, etc., but are called standard lines. Dipping, spraying, etc. indicate the nature of the line (automatic-continuous, etc.) rather than the particular process.

Industrial plant equipment (IPE) is the base of the study. Other plant equipment (OPE) is discussed only where it is necessary to clearly identify the process requirements.

Press capabilities and capacities are extracted from accepted existing authorities.

The model line for the M107 body is a composite of the three most commonly used projectile forging processes: cold forming or drawing, hot forging, and a combination of the two processes called hot cup, cold draw. All currently used processes are listed against each required operation, and a sequence of operations is constructed that will facilitate the entire manufacturing cycle in a continuous manner.

The model lines for the base and ogive are a composite of the operations and equipment used to produce each part. An analysis of each part is also included.

The M483 should be produced by the hot forge, heat treat process to obtain the required mechanical properties, although it may be possible to cold work after initial hot forging, followed by heat treating to achieve the necessary properties.

The operations needed to manufacture the M107 body, including the nstallation of the rotating band, are clearly delineated in the operational procedure for the body.

III. PROCESS DESCRIPTION SUMMARY

The Process Description Summary following this page shows the applicability of the operation and equipment type to a major manufacturing process (hot forge, heat treat; hot cup, cold draw; and/or cold extrusion). The meaning of the codes listed for the alternatives is as follows:

HF107	Hot forge, heat treat process for the 155mm M107 projectile Material: Steel, AISI 1055
HC107	Hot cup, cold draw process for the 155mm M107 projectile Material: Steel, AISI 1012
CE107	Cold extrusion process for the 155mm M107 projectile Material: Steel, AISI 1012
HF483	Hot forge, heat treat process for the 155mm M483 projectile Material: Steel, AISI 4140; Alt, AISI 1340

Equipment used to perform each operation, including alternative machines (identified as EQ ALT) if applicable, are also listed. Operations that apply to only one end item or process are designated as such.

The order in which the operations are performed is shown by the operation number. These are four-digit numbers with the first character designating the end item for that line and the balance indicating the numerical sequence of operations.

Opposite the operation number is a description of the operation with the equipment used listed below it. Under operation sequence, a path is shown by X's indicating steps of manufacture. If an alternative method of manufacture is available, it is shown by a branch from the main path.

Gross capacities listed are estimated production capabilities of the equipment designated for the operation and are shown in pieces per hour. These figures are not factored for downtime or delays. As an example, a press that is capable of cycling in 10 seconds (i.e., 6 cycles per minute) will have a gross capacity of 360 pieces per hour.

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
***** BODY *****							
1110		Handle Billet		X	X	X	X
	1	Material handling equip - 2000 lb	9				
1120		Heat Billet		X	X		X
	1	Heater, induction - 4200 kw	9				
	2	Furnace, walking beam, gas - 2200 F	9				
	3	Furnace, walking beam, oil - 2200 F	9				
1130		Separate Mults		X	X		X
	1	Shear, hot - 350 T	180				
	2	Shear, cold - 2200 T	180				
	3	Saw, carbide tip - 75 hp	80				
	4	Saw, band - 50 hp	50				
	5	Torch & press - 350 T	210				
1130		Separate Mults				X	
	1	Saw, carbide tip - 75 hp	80				
	2	Saw, band - 50 hp	50				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1140		Heat Mult		X	X		X
	1	Heater, induction - 4000 kw	30				
	2	Furnace, rotary hearth - 2200 F	180				
	3	Furnace, salt bath - 2200 F	180				
1150		Descale		X	X		X
	1	Cabinet, water jet auto feed	180				
	2	Rolls, sizing - 40 hp	180				
1160		Phosphate & Lubricate				X	
	1	Chemical line	200				
1170		Slugging (cold sizing)				X	
	1	Press, hydraulic - 3500 T	80				
1180		Cabbage & Pierce		X	X		X
	1	Press, mechanical - 2500 T	180				
	2	Press, hydraulic - 600 T	110				
1190		Back Extrude				X	
	1	Press, hydraulic - 3000 T	75				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1200		Pierce		X	X		
	1	Press, hydraulic - 500 T	200				
1210		Draw		X			
	1	Press, hydraulic - 300/400 T	200				
1220		Draw & Pierce Nose					X
		Press, hydraulic - 400 T	180				
1225		Cool			X		
	1	Tunnel, cooling	180				
1230		Anneal				X	
	1	Heater, induction - 200 kw	100				
	2	Furnace, oil/gas - 1250 F	100				
1235		Descale Inside Diameter			X		
	1	Cabinet, abrasive cleaning - 75 hp	100				
1237		Machine Forging			X		
	1	Lathe, auto tracing - 125 hp	40				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1240		Phosphate & Lubricate			X	X	
	1	Chemical line	200				
1250		Cool		X			X
	1	Tunnel, cooling	180				
1260		Forward Extrude			X	X	
	1	Press, hydraulic - 3000 T	75				
1270		Coin Boattail			X	X	
	1	Press, hydraulic - 3000 T	50				
1285		Descale Outer Surface		X			X
	1	Cabinet, shot blast - 75 hp	165				
1290		Descale Inner Surface		X			X
	1	Cabinet, shot blast - 40 hp	100				
1300		Phosphate & Lubricate			X	X	X
	1	Chemical line	200				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1305		Cold Draw & Coin					X
	1	Press, hydraulic - 400 T	115				
1307		Stress relieve					X
	1	Furnace - 1200 F	40				
1310		Cold Draw			X	X	
	1	Press, hydraulic - 1000 T	25				
1315		Form Bourrelet				X	
	1	Press, hydraulic - 600 T	45				
1320		Turn Center					X
	1	Lathe, auto chucking	200				
1330		Center Drill, Closed End		X			
	1	Lathe, auto chucking - 30 hp	200				
1340		Trim Nose			X	X	
	1	Lathe, auto chucking - 20 hp	80				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1350		Rough Turn Outside Diameter & Cutoff		X			X
	1	Lathe, auto chucking - 30 hp	50				
1370		Heat Open End		X			
	1	Heater, induction - 200 kw	40				
1380		Anneal Nose End			X	X	
	1	Heater, induction - 200 kw	40				
	2	Furnace, salt bath - 1200 F	20				
1390		Phosphate & Lubricate			X	X	X
	1	Chemical line	200				
1410		Form Nose			X	X	
	1	Press, hydraulic - 1000 T	110				
1415		Form Nose		X			
	1	Press, hydraulic - 350 T	110				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1420		Form Undercut					X
	1	Machine, shear forming (special)	30				
	2	Cold swaging	35				
	3	Lathe, auto chucking - 30 hp	50				
1430		Heat Treat		X			
	1	Heater, induction - 400 kw	16				
	2	Furnace, gas - 1550/1650 F	16				
1440		Stress Relieve			X	X	X
	1	Heater, induction - 200 kw	30				
1450		Cool		X	X	X	X
	1	Tunnel, cooling	180				
1455		Descale Cavity		X			
	1	Cabinet, shot blast - 75 hp	100				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1460		Bore, Face & Chamfer Nose		X	X	X	
	1	Lathe, auto chucking - 25 hp	100				
	2	Lathe, NC - 25 hp	110				
1465		Turn Body & Ogive		X			
	1	Lathe, auto chucking - 30 hp	55				
	2	Lathe, NC - 30 hp	55				
1467		Face Base & Turn Boattail		X			
	1	Lathe, auto chucking - 30 hp	40				
	2	Lathe, NC - 30 hp	40				
1470		Turn Band Seat & Face Base		X	X	X	X
	1	Lathe, multipass tracing - 20 hp	125				
	2	Lathe, NC - 20 hp	125				
1480		Clean					X
	1	Cleaning line	200				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107 HC107 CE107 HF483
1490		Weld Band		X
	1	Welder, MIG - 250 kva	12	
	2	Welder, TIG - 500 kva	12	
	3	Welder, plasma arc - 500 kva	12	
	4	Welder, inertia - 15 hp	30	
1500		Rough Turn Band		X
	1	Lathe, auto chucking	150	
1510		Heat Treat & Temper		X
	1	Heater, induction - 400 kw	16	
	2	Furnace, gas - 1550/1650 F	16	
1520		Bore, Face & Chamfer Nose		X
	1	Lathe, auto chucking - 25 hp	110	
1530		Turn Outside Diameter		X
	1	Lathe, auto chucking - 25 hp	55	
	2	Lathe, NC - 25 hp	55	

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1535		Finish Bore Inside Diameter					X
	1	Lathe, high speed chucking - 20 hp	50				
	2	Lathe, NC - 20 hp	50				
1540		Counterbore & Face Rear End					X
	1	Lathe, auto chucking - 30 hp	100				
	2	Lathe, NC - 30 hp	100				
1560		Slot Inside Diameter					X
	1	Keyway cutter - 7 hp	20				
1565		Knurl Band Seat		X	X	X	
	1	Knurling machine - 15 hp	60				
1570		Clean					X
	1	Cleaning line	350				
1580		Thread Ends					X
	1	Machine, threading - 20 hp	35				
	2	Lathe, chucking, tap & die - 20 hp	20				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1590		Grind Bourrelet		X	X	X	X
	1	Grinder, centerless - 50 hp	80				
1592		Clean		X	X	X	
	1	Cleaning line	350				
1595		Install Band		X	X	X	
	1	Press, special assembly	40				
1597		Finish Machine Band		X	X	X	
	1	Lathe, tracer - 25 hp	125				
	2	Lathe, NC - 25 hp	125				
1600		Stamp Identification					X
	1	Machine, stamping, rotary - 5 hp	200				
1610		Phosphate Treat					X
	1	Chemical line, multistage	225				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1620		Wrap Fiberglass					X
	1	Machine, wrapping, filament	15				
	2	Machine, wrapping, preimpregnated mat	20				
1630		Cure Fiberglass					X
	1	Oven, curing - 15 kw	20				
	2	Oven, heat lamp - 15 kw	20				
	3	Oven, ultra violet lamp - 15 kw	20				
1640		Finish Turn Fiberglass					X
	1	Lathe, auto chucking - 20 hp	50				
1650		Finish Machine Band					X
	1	Lathe, tracer - 25 hp	125				
1660		Thread Nose		X	X	X	
	1	Machine, tapping - 15 hp	40				
1670		Weld Base Cover		X	X	X	
	1	Welder, resistance - 60 kva	60				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
1680		Stamp Identification		X	X	X	
	1	Machine, rotary stamping - 5 hp	200				
1690		Phosphate Treat		X	X	X	
	1	Chemical line, multistage	225				

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
***** BASE *****							
2110		Handle Bars				X	
	1	Material handling equipment - 250 lb	9				
2120		Separate Slug				X	
	1	Saw, band - 50 hp	600				
	2	Saw, circular - 75 hp	200				
2130		Deburr Slug				X	
	1	Vibratory system - 50 hp	300				
	2	Machine, auto chamfer - 30 hp	300				
2140		Lubricate Slug				X	
	1	Spray/dip line & induc heater - 200 kw	240				
2150		Heat Slug				X	
	1	Heater, induction - 300 kw	240				
	2	Furnace, gas - 850 F	220				
	3	Furnace, oil - 850 F	220				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr
2160		Preform	
	1	Press, mechanical - 400 T	480
2160		Preform & Form	
	1	Press, mechanical - 1000 T	480
2165		Form	
	1	Press, mechanical - 400 T	480
2170		Clean	
	1	Chemical line	225
2180		Heat Treat	
	1	Furnace - 900 F, qnch tnk & oven - 250 F	195
2190		Machine Outside Dia, Rear, & Thread	
	1	Lathe, multispndl, auto chucking - 25 hp	190

Operation Sequence
HF107 HC107 CE107 HF483

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PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107 HC107 CE107 HF483
2200		Drill & Deburr Spanner Holes		
	1	Drill, multispindle - 1/2 hp	240	X
2210		Hard Coat		
	1	Chemical line	200	X

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
***** OGIVE *****							
3110		Handle Bars					
	1	Material handling equipment - 250 lb	9	X			
3120		Separate Slug					
	1	Saw, band - 25 hp	600		X		
	2	Saw, circular - 35 hp	200				
3130		Deburr Slug					
	1	Vibratory system - 50 hp	300			X	
	2	Machine, auto chamfer - 20 hp	300				
3140		Lubricate Slug					
	1	Spray/dip line & induc heater - 200 kw	240				X
3150		Heat slug					
	1	Heater, induction - 300 kw	240				X
	2	Furnace, oil - 850 F	220				
	3	Furnace, gas - 850 F	220				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
3160		Preform					X
	1	Press, mechanical - 400 T	450				
3160		Preform, Form, Coin & Pierce					X
	1	Press, mechanical - 1000 T	450				
3165		Form					X
	1	Press, mechanical - 400 T	450				
3170		Coin & Pierce					X
	1	Press, mechanical - 400 T	450				
3180		Clean					X
	1	Chemical line	220				
3190		Heat Treat					X
	1	Furnace - 900 F	195				
3195		Finish Machine Outside Dia & Face Rear					X
	1	Lathe, multipass, auto tracing - 25 hp	120				
3200		Finish Machine & Thread Nose					X
	1	Lathe, multipass, auto chucking - 25 hp	110				

PROCESS DESCRIPTION SUMMARY
155MM PROJECTILE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence HF107	HC107	CE107	HF483
3210		Finish & Thread Rear					X
	1	Lathe, multipass, auto tracing - 25 hp	100				
3220		Chromate					X
	1	Chemical line	200				

IV. ANALYSIS OF OPERATIONS

A. PROJECTILE BODY (155MM M483/M107) - See Figures IV-1 and IV-2

1. Operation 1110 - Handle Billet M483/M107

Equipment - Standard cranes, hoists, and transfer equipment

The handling of steel billets is not a step in the production process, but the materials handling problem must be anticipated in any line of this type that is designed for high tonnage consumption of steel billets. These operations must be considered, as discussed below.

a. Receiving Bulk Stock

This operation includes the movement of rolling stock, trailers, and the actual stacking of material in the storage areas. Unloading activity will utilize overhead cranes, forklifts, and jib cranes. Stacking must be of a nature to assure material traceability.

Receiving inspection must be completed before a lot becomes available for processing. If material supplier certification is acceptable, verification of quantity, either by weight or length, can be accomplished without extra handling.

b. Movement of Billet from Bulk Storage to First Process Station, 6-Inch RCS, 2000 lb Each

This operation includes:

- Separating stock into single billets. Special handling equipment such as magnets, hooks, grapples, slings, and hoists will be needed.
- The continuous processing of the individual billets through weighing devices, metallurgical scanning, and physical measuring devices. This activity is required to develop the correct mult weight to be generated at the billet separation

operation. A computerized system to scan weight and length would be the preferred control system. Although the system will not increase the yield per billet, it should assure the cutting of mults to the required weight.

- o Movement of the billet through separation operation. This activity involves controlling the alignment and progression of the billet and the handling of rejects. Included must be any additional functions such as multiple racking, saw trim requirements, and possible laydown or holding requirements.

2. Operation 1120 - Heat Billet M483/M107

Equipment - Furnace, continuous tunnel, 2200 F, 300 lb/min

Equipment alternatives
- Heater, induction, 4200 kw, 400 Hz
- Beam, walking, gas
- Beam, walking, oil

This heating operation is used in conjunction with a hot shearing procedure. The billet will be fed continuously through the tunnel, exiting at the desired temperature prior to shearing. Overtemperature controls must be included to handle a line stoppage problem.

3. Operation 1130 - Separate Mults M483/M107

Equipment alternatives
- Press, 350 ton (hot shearing)
- Press, 2200 ton (cold shearing)
- Saw, carbide tipped, 75 hp (sawing)
- Saw, band, 50 hp (sawing)
- Press, 350 ton and torch (nick and break)

The weighing of each mult is an integral part of this operation.

a. Hot Shear

A 350-ton shear press requires automatic feed, clamp, and eject attachments. The press should be part of the production line, as the hot mult may have to be processed through descale, cabbage, and pierce without further heating to achieve maximum efficiency within the process.

b. Cold Shear

The 2200-ton shear press requires automatic feed, clamp, and eject attachments. The press may be in the production line to minimize material handling and traceability problems, but the press can be off line if facilities dictate.

c. Circular Saw

Carbide tipped circular saws produce precision mult.

d. Band Saw

The band saw is less accurate but less expensive than a circular saw. The band sawing process is slow, compared to the forging rate; therefore, material handling provisions must be developed for multiple machines.

Abrasive cutting, even wet, is not approved. Experience has shown that trapped abrasive causes excessive tool wear during forging.

e. Nick and Break

This process is based on the concentration of a stress in the cold billet, called the nick, followed by a cold breaking operation.

A 350-ton press and a good holddown system are required to break the billet. This operation is not as accurate as hot shearing, but it requires less capital investment and lower cost tooling.

f. Flame Cutting

Flame cutting is not recommended because it is slow, wasteful of material, and may affect the metallurgy of the mult.

4. Operation 1140 - Heat Mult M483/M107

Equipment - Continuous tunnel furnace, 2200 F, 300 lb/min, 6-inch RCS

Equipment alternatives
- Heater, induction, 4000 kw, 400 Hz
- Rotary hearth kilns
- Furnaces, salt bath

This step is required for the hot forging and the hot cup, cold draw processes. Time at temperature should be long enough to assure uniform heating, but excessive soak time should be avoided due to the high rate of scaling.

5. Operation 1150 - Descale M483/M107

Equipment alternatives
- Cabinet, water jet automatic feed
- Rolls, sizing, 40 hp

a. The removal of scale from hot mults prior to forging is accomplished by water jets. Water pressures of 1200 to 2200 psi and flow rates of 1/2 to 2 gallons per second are normally used. Power feeding of the hot mults is by chain conveyor or pusher.

b. An alternative method for removing scale is to mechanically crack the scale with rolls, dies, etc. This process is not commonly used.

6. Operation 1160 - Phosphate and Lubricate M107

Equipment - Chemical line

Forgings subject to subsequent cold work require proper surface preparation to prevent galling of the tooling. Conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include

soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

7. Operation 1170 - Slugging (Cold Sizing) M107

Equipment - Press, hydraulic, 3500-ton, 12-inch stroke

This is the first step in cold working, generally termed "filling the die."

8. Operation 1180 - Cabbage and Pierce M483/M107

Equipment alternatives
- Press, mechanical, 2500-ton, 48-inch stroke
- Press, hydraulic, 600-ton, 48-inch stroke

The cabbage step causes the heated square mult to assume the shape of the round die. Once sized, the first major movement of metal is accomplished, with or without reheat, in the pierce step. The uniformity of metal flow determines the effectiveness of the balance of succeeding forging operations for the overall dimensional accuracy and level of quality.

9. Operation 1190 - Back Extrude M107

Equipment - Press, hydraulic, 3000-ton, 48-inch stroke

Back extrusion is a cold process that causes the metal to move backward over the mandrel to form the first shape (bottle). The process can be combined with cold sizing, but an intermediate anneal may be required.

10. Operation 1200 - Pierce M107

Equipment - Press, hydraulic, 500-ton, 60-inch stroke

The pierce step is a hot working process that forms the sized mult to an intermediate hollow length by a backward extrusion technique.

11. Operation 1210 - Draw M107

Equipment - Press, hydraulic, 300/400-ton, 72-inch stroke

The body is hot drawn to final length, and the wall thickness is reduced as the body is extended through rings and over a mandrel.

12. Operation 1220 - Draw and Pierce Nose M483

Equipment - Press, hydraulic, 400-ton, 72-inch stroke

The M483 body is open at both ends. It is now drawn to length, and during the same stroke, the end is simultaneously pierced.

13. Operation 1225 - Cool M107

Equipment - Tunnel, cooling

Alloy and high carbon steels have mechanical properties that are sensitive to cooling rates from forging temperatures. To produce the best possible metallurgical structure for subsequent cold forming and machining operations, the cooling environment must be slow. Also, slower cooling introduces fewer thermal stresses and less warpage.

14. Operation 1230 - Anneal M107

Equipment - Furnace, continuous tunnel, 1250 F

Equipment alternatives
- Heater, induction, 200 kw, 400 Hz
- Furnace, oil/gas

The annealing step facilitates further forming operations. It must be accomplished at this time to assure uniformity of metal deformation. Scaling will require a subsequent chemical or mechanical cleaning prior to further processing.

15. Operation 1235 - Descale Inside Diameter M107

Equipment - Cabinet, abrasive cleaning, 75 hp

The descaling by abrasive cleaning is necessary prior to subsequent machining and forming operations.

16. Operation 1237 - Machine Forging (Bottle) M107

Equipment - Lathe, auto tracer, 8-inch swing, 48-inch centers, 125 hp

Rough machine forging to remove metal defects and correct wall variations.

17. Operation 1240 - Phosphate and Lubricate M107

Equipment - Chemical line

Forgings subject to subsequent cold work require proper surface preparation to prevent galling of the tooling. Conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

18. Operation 1250 - Cool M483/M107

Equipment - Tunnel, cooling

Alloy and high carbon steels have mechanical properties that are sensitive to cooling rates from forging temperatures. To produce the best possible metallurgical structure for subsequent cold forming and machining operations, the cooling environment must be slow. Also, slower cooling introduces fewer thermal stresses and less warpage. Cooling tunnels are desirable but the use of bulk insulation is more common.

19. Operation 1260 - Forward Extrude M107

Equipment - Press, hydraulic, 3000-ton, 72-inch stroke

This cold working process requires an annealed extrusion as starting material. The forward extrusion thins the wall.

20. Operation 1270 - Coin Boattail M107

Equipment - Press, hydraulic, 3000-ton, 36-inch stroke

The metal in the boattail was not worked in the preceding cold extrusion step and therefore does not require an anneal.

The metal is subsequently cold sized in the coining operation.

21. Operation 1285 - Descale Outer Surface M483/M107

Equipment - Cabinet, shot blast, automatic feed, 75 hp

The removal of scale from the outer surface of the forging is accomplished by steel shot propelled at high velocity and impinging against the surface while being conveyored on skewed and tapered rolls in order to expose total surface to the scaling media.

22. Operation 1290 - Descale Inner Surface M483/M107

Equipment - Cabinet, shot blast, automatic feed, 40 hp

The removal of scale from the inner surface of the forging is accomplished by steel shot propelled at high velocity and impinging against the inner surface while the forging is rotated in a vertical position for total exposure to the scaling media.

23. Operation 1300 - Phosphate and Lubricate M483/M107

Equipment - Chemical line

Forgings subject to subsequent cold work require proper surface preparation to prevent galling of the tooling. Chemical coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

24. Operation 1305 - Cold Draw and Coin M483

Equipment - Press, hydraulic, 400-ton, 120-inch stroke

This cold draw process shapes the body and establishes wall thickness for subsequent machining. The outside diameter of the nose and inside radius are sized in the coining die.

25. Operation 1307 - Stress Relieve M483

Equipment - Furnace, 1200 F, 10- ton capacity

The residual stresses developed by cold working are reduced to facilitate machining and to minimize distortion and cracking.

26. Operation 1310 - Cold Draw M107

Equipment - Press, hydraulic, 1000-ton, 72-inch stroke

This cold draw process shapes the body and establishes wall thickness for subsequent machining.

27. Operation 1315 - Form Bourrelet M107

Equipment - Press, hydraulic, 600-ton, 48-inch stroke

The above forming operation may be used on the cold worked process for shaping the bourrelet and to dispense with subsequent body machining. This process is not in use at this time.

28. Operation 1320 - Turn Center M483

Equipment - Lathe, automatic chucking, 8-inch swing, 36-inch centers, 20 hp

This operation centers the body held with internal chucking for final processing. The remaining operations of this process form to specific controlled dimensions. The forging must be centered accurately at this stage to achieve final concentricity and weight.

29. Operation 1330 - Center Drill - Closed End M107

Equipment - Lathe, automatic chucking, 8-inch swing, 48-inch centers, 30 hp

This operation provides the center for subsequent turning operations.

30. Operation 1340 - Trim Nose M107

Equipment - Lathe, automatic chucking, 8-inch swing, 48-inch centers, 20 hp

After cold extrusion, nonuniform metal deformation and excess metal are found at the end of the shell and must be removed prior to nosing.

31. Operation 1350 - Rough Turn Outside Diameter and Cutoff M483/M107

Equipment - Lathe, automatic chucking, 8-inch swing, 48-inch centers, 30 hp

This operation corrects body concentricity deficiencies and removes excess weight prior to a cold draw operation.

32. Operation 1370 - Heat Open End M107

Equipment - Heater, induction, 1400 F, 200 kw, 400 Hz

The open end of the shell requires heating just prior to the nosing operation. A convenient heating method is induction heating to 1200/1400 F.

33. Operation 1380 - Anneal Nose M107

Equipment alternatives
- Heater, induction, 1200 F, 200 kw, 400 Hz
- Furnace, salt bath, 1200 F

The cold drawn shell obtains much of its mechanical properties through cold working. To soften the nose area enough for another operation requires a rapid heating and cooling cycle to 1200 F. Cooling rings are often employed to prevent the spread of heat into the balance of the shell.

34. Operation 1390 - Phosphate and Lubricate M483/M107

Equipment - Chemical line

Forgings subject to subsequent cold work require proper surface preparation to prevent galling of the tooling. Conversion coats of the phosphate type are used universally to

provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

35. Operation 1410 - Form Nose M107

Equipment - Press, hydraulic, 1000-ton, 24-inch stroke

The forming of the nose is done cold for the extrusion and hot cup, cold draw process.

36. Operation 1415 - Form Nose M107

Equipment - Press, hydraulic, 350-ton, 24-inch stroke

Forming the nose is done hot for the hot forge, heat treat process.

37. Operation 1420 - Form Undercut M483

Equipment alternatives
- Machine, special shear-forming
- Cold swaging
- Lathe, automatic chucking, 8-inch swing, 36-inch centers with tracer attachment, 30 hp

The shell weight must be reduced by thinning the shell side wall in the center of the shell. This can be accomplished by shear forming or cold swaging or by turning on a lathe.

38. Operation 1430 - Heat Treat M107

Equipment alternatives
- Heater, induction 1550/1650 F, 400 kw, 400 Hz
- Furnace, gas 1550/1650 F

The strength of the case after hot forging is achieved with an austenitizing, quenching, and tempering heat treatment. Furnace or induction heating is used to austenitize at 1550 to 1650 F. Quenching should be by spray or immersion in an agitated bath. The M107 is a closed-end shell and must have special provisions to assure quenching the inside diameter.

Tempering is accomplished in a standard, lower temperature oven.

39. Operation 1440 - Stress Relieve M483/M107

Equipment - Heater, induction, 1200 F, 200 kw, 40 Hz

This operation will only be required if Operation 1420 for the M483 is performed by shear forming or cold swaging. It will be used in conjunction with hot cup, cold draw and cold extrusion processes for the M107 only.

40. Operation 1450 - Cool M483/M107

Equipment - Tunnel, cooling

The requirement for controlled and slower cooling is marginal but does contribute to a lessening of thermal stresses after the stress relief operation.

41. Operation 1455 - Descale Cavity M107

Equipment - Cabinet, shot blast automatic feed, 75 hp

The removal of scale from the inner surface of the forging is accomplished by steel shot propelled at high velocity and impinging against the inner surface while the forging is rotated in a fixed, vertical position for total exposure to the descaling media.

42. Operation 1460 - Bore, Face, and Chamfer Nose M107

Equipment alternatives

- Lathe, automatic chucking, high speed tracer, 25 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 25 hp

Standard machining operation.

43. Operation 1465 - Turn Body and Ogive M107

Equipment alternatives
- Lathe, automatic chucking, high speed tracer, 30 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 30 hp

Standard machining operation.

44. Operation 1467 - Face Base and Turn Boattail M107

Equipment alternatives
- Lathe, automatic chucking, high speed tracer, 30 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 30 hp

Standard machining operation.

45. Operation 1470 - Turn Band Seat and Face Base M483/M107

Equipment alternatives
- Lathe, multipass tracer, 20 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 20 hp

This operation combines grooving the body and facing the base for subsequent rotating band assembly.

46. Operation 1480 - Clean M483

Equipment - Cleaning line

Standard cleaning processes to prepare steel alloy for welding.

47. Operation 1490 - Weld Band M483

Equipment alternatives
- Welder, MIG, 250 kva
- Welder, TIG, 500 kva
- Welder, plasma arc, 500 kva
- Welder, inertia, 15 hp

Inert gas welding is used to rough form the rotating band by weld build up to the body. The MIG, TIG, and plasma processes are approximately interchangeable except for welding speed. A minimum amount of heat should be used to prevent excessive dilution and overtempering of the heat treated body. Inertia welding has been proposed and if successful, would be more economical.

48. Operation 1500 - Rough Turn Band M483

Equipment - Lathe, automatic chucking with 8-inch swing, 48-inch centers, 25 hp

Combination trimming and turning the band requires both plunging and turning capabilities on the lathe to generate the correct band shape.

49. Operation 1510 - Heat Treat and Temper M483

Equipment alternatives
- Heater, induction 1550/1650 F, 400 kw, 400 Hz
- Furnace, gas 1550/1650 F

The strength of the case after hot forging is achieved with an austenitizing, quenching, and tempering heat treatment. Furnace or induction heating is used to achieve 1550 to 1650 F. Quenching should be by spray or immersion in an agitated bath.

50. Operation 1520 - Bore, Face, and Chamfer Nose M483

Equipment - Lathe, automatic chucking, 8-inch swing, 48-inch centers, 25 hp

Standard machining operation.

51. Operation 1530 - Turn Outside Diameter M483

Equipment alternatives
- Lathe, automatic chucking, high speed tracer, 25 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 25 hp

The finishing pass on the outside of the body produces the final surface for the outside diameter, the bourrelet, and the body undercut. If the bourrelet is not produced to final configuration, a centerless grinding operation (Operation 1590) is required.

52. Operation 1535 - Finish Bore Inside Diameter M483

Equipment alternatives
- Lathe, high speed chucker, 20 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 20 hp

This operation should be performed on a hollow spindle lathe for rigidity and increased accuracy. An alternative lathe would include a special pot chuck. If excessive metal must be removed, a roughing cut and a finish cut may be required in place of a single finish cut. The boring operation is being done on the heat treated body, thus increasing power requirements.

53. Operation 1540 - Counterbore and Face Rear End M483

Equipment alternatives
- Lathes, automatic chucking, high speed tracer, 30 hp
- Lathe, numerical controlled, 8-inch swing, 48-inch centers, 30 hp

Standard machining operation.

54. Operation 1560 - Slot Inside Diameter M483

Equipment - Keyway cutter (seater), 28-inch stroke, 7 hp

A blind slotted keyway is required on the inside diameter of the shell and, for reasons of accuracy, must be cut after heat treating. The length of the slot, the mechanical properties of the base metal, and the blind nature of the slot require a special machine with rigid support.

55. Operation 1565 - Knurl Band Seat M107

Equipment - Knurling machine, 15 hp

The band on the M107 is held in place by a mechanical interference fit with the body. The knurling process is designed to increase the mechanical bond of the interface.

56. Operation 1570 - Clean M483

Equipment - Cleaning line

This is a standard cleaning process to remove chips and residual oils developed by preceeding machining operations.

57. Operation 1580 - Thread Ends M483

Equipment alternatives
- Machine, threading, dual or single head, 20 hp
- Lathe, chucking with tap and die, 8-inch swing, 48-inch centers, 20 hp

The M483 requires threading at both ends after hardening. Equipment must be in good condition and the best threading techniques must be used. This operation can be combined with earlier operations.

58. Operation 1590 - Grind Bourrelet M483/M107

Equipment - Grinder, centerless, automatic feed, 50 hp

This is a finishing operation required only if the finishing operation is not performed at the last turning operation of the outside diameter (Operation 1530).

59. Operation 1592 - Clean M107

Equipment - Cleaning line

This is a standard cleaning process to remove any chips or abrasive prior to installation of the rotating band.

60. Operation 1595 - Install Band M107

Equipment - Press, special band assembly

The rotating band is installed over the previously dovetailed and knurled area of the body band slot.

61. Operation 1597 - Finish Machine Band M107

Equipment alternatives
- Lathe, tracer with plunge attachment, 25 hp
- Lathe, numerical control, 8-inch swing, 48-inch centers, 25 hp

The band requires finish machining after welding or pressing in place. This operation finishes the band to the required outside diameter.

62. Operation 1600 - Stamp Identification M483

Equipment - Machine, stamping, rotary, 5 hp

The stamping is performed on a horizontal rotating fixture at which time the nomenclature, date of manufacture, lot number, and contractor's identification are indented.

63. Operation 1610 - Phosphate Treat M483

Equipment - Chemical line (multistage spray/dip system)

This process is to remove foreign particles and prepare the surface for subsequent painting operations.

64. Operation 1620 - Wrap Fiberglass M483

Equipment alternatives
- Machine, wrapping, special filament
- Machine, wrapping, preimpregnated mat

This operation is used to fill the undercut portion in the body. A conventional lay-up process can be used or a preimpregnated fiberglass mat may be used.

65. Operation 1630 - Cure Fiberglass M483

Equipment alternatives
- Oven, curing, 15 kw
- Oven, heat lamp, 15 kw
- Oven, ultra violet lamp, 15 kw

The adhesive applied to the fiberglass requires undisturbed curing of the glue line until the curing temperature is

reached. The heat and time cycle is a function of the particular type of adhesive.

66. Operation 1640 - Finish Turn Fiberglass M483

Equipment - Lathe, automatic chucking, 8-inch swing, 48-inch centers, 20 hp

The body is located against the base end and chucked by an expanding mandrel for proper holddown. The fiberglass is then machined in order to meet configuration requirements. The disadvantages are: removal of the "buttering" or outer surface results in exposed sheared glass fibers (no longer continuous strands), potentially resulting in a weakened structure and a health hazard generated by the glass fibers.

67. Operation 1650 - Finish Machine Band M483

Equipment - Lathe, tracer with plunge attachment, 8-inch swing, 48-inch centers, 25 hp

The bands require finish machining after being welded in place. This operation brings the band to the required outside diameter.

68. Operation 1660 - Thread Nose M107

Equipment - Machine, special tapping, 15 hp

This operation is performed in order to generate the required thread at the nose end.

69. Operation 1670 - Weld Base Cover M107

Equipment - Welder, special resistance, 60 kva

A piece of thin gage steel is welded to the base of the body to guarantee that no preignition of the explosive will occur during propellent burn. The welding process consists of a series of overlapping welds to assure positive closure.

70. Operation 1680 - Stamp Identification M107

Equipment - Machine, rotary stamping, 5 hp

The stamping is performed on a horizontal or vertical rotating fixture at which time the nomenclature, date of manufacture, lot number, and contractor's identification are indented.

71. Operation 1690 - Phosphate Treat M107

Equipment - Chemical line (multistage spray/dip system)

This process removes foreign particles and prepares the surface for painting.

B. BASE (155MM M483) - See Figure IV-3

Material - Aluminum alloy 7075-F, 3-1/2 inch diameter rounds

1. Operation 2110 - Handle Bars

Equipment - Transfer equipment, sorting table, forklift, and standard cranes (250-lb bars)

This operation involves the transport of aluminum bar in bundles to sorting tables where they are unbanded and sorted for the succeeding operation.

2. Operation 2120 - Separate Slug

Equipment alternatives
- Saw, band, 50 hp
- Saw, circular, 75 hp

Band sawing is less accurate and slower than circular sawing for this application, due to the high volume of production. High speed circular saw cutting will result in better cutting accuracy and a higher production rate. In the latter method, stack-bar cutting or multihead saw cutting is readily applicable.

3. Operation 2130 - Deburr Slug

Equipment - Vibratory system, 50 hp
- Machine, automatic chamfering, 30 hp

Deburring the ends of the slug is necessary to achieve the proper configuration prior to forging. Also, deburring will minimize potential damage to the forging die. A vibratory system can accommodate multislug deburring, and with the proper speeds and media selections, the slugs become burr free and useable. The use of an automatic chamfering machine will effect a preferred deburred edge at slightly higher cost with the use of a double-ended flycutter technique with automatic load and unload mechanization.

4. Operation 2140 - Lubricate Slug

Equipment - Spray/dip line and heater, induction, 300 F, 200 kw, 400 Hz

Slugs subject to subsequent forming require surface lubricants in order to reduce the frictional forces and to maintain longer tool life. The lubrication process is preceded by heating the slugs to 300 F followed with a spray or dip using a water based colloidal graphite suspension.

5. Operation 2150 - Heat Slug

Equipment - Furnace, continuous tunnel, 850 F, 1350 lb/hr

Equipment alternatives
- Heater, induction, 300 kw, 400 Hz
- Oil burners
- Gas burners

The slug is heated to 850 F in a continuous furnace preceding the forging operations. This step is necessary for the alloy selected and to reduce press capacity. It facilitates the forging processes.

6. Operation 2160 - Preform

Equipment - Press, mechanical, 400-ton, 20-inch stroke

The lubricated and heated slug is placed in the die and forged to the preform shape. This is the first of two steps in the hot forging operation.

Equipment - Press, mechanical, 1000-ton, 24-inch stroke

The lubricated and heated slug is placed in the first cavity of the press and preformed as the first step in the hot forging process. It is immediately transferred to the second station in the same press for the forming step (Operation 2165) to achieve the final forged shape. Both steps must be accomplished in mimumum time to prevent excessive heat loss. Forging can be accomplished in both stations simultaneously, to achieve maximum productivity in the press.

7. Operation 2165 - Form

Equipment - Press, mechanical, 400-ton, 24-inch stroke

The heated preform from Operation 2160 is the starting material for this operation. If the preform is cooled before the forming step is accomplished, cleaning, lubrication, and heating will be required prior to forming. The preform is placed in the die and formed by a backward extrusion in one stroke.

8. Operation 2170 - Clean

Equipment - Chemical line

The purpose of this operation is to remove lubricant and foreign materials from the forging.

9. Operation 2180 - Heat Treat

Equipment - Furnace, 900 F, 1350 lb/hr, quench tank and aging oven, 250 F

The purpose of this process is to attain the required mechanical properties in the final part. The forged base is exposed to a 2-hour cycle at 900 F, quenched in water at 150 F, and aged for 28 hours at 250 F.

10. Operation 2190 - Machine Outside Diameter, Rear End and Thread 5.375 Inch-20UNS

Equipment - Lathe, multispindle, automatic chucking 8-inch swing, 25 hp

The forged base is held internally by an expanding mandrel and the outer surface is machined completely and threaded.

11. Operation 2200 - Drill and Deburr Spanner Holes

Equipment - Drill, special multispindle, machine, 1/2 hp

This machined base is located in a holding fixture and the two spanner holes are drilled and deburred.

12. Operation 2210 - Hard Coat

Equipment - Chemical line

After masking the threads, the base is processed through a multistage cleaning, etching, and hard anodizing bath for protective and functional purposes.

C. OGIVE (155MM M483) - See Figure IV-4

Material - Aluminum alloy 7075-F, 3-1/2 inch diameter rounds

1. Operation 3110 - Handle Bars

Equipment - Transfer equipment, sorting table, forklift and standard cranes (250-lb bars)

This operation involves the transport of aluminum bars in bundles to sorting tables where they are unbanded and sorted for the succeeding operation.

2. Operation 3120 - Separate Slug

Equipment alternatives
- Saw, band, 25 hp
- Saw, circular, 35 hp

Band sawing is less accurate and slower than a circular saw for this application, due to the high volume of production. High speed circular saw cutting will result in better cutting accuracy and a higher production rate. In the latter method, stack-bar cutting or multihead saw cutting is readly applicable.

3. Operation 3130 - Deburr Slug

Equipment alternatives
- Vibratory system, 50 hp
- Machine, automatic chamfering, 20 hp

Deburring the ends of the slug is necessary to achieve the proper configuration prior to forging. Also, deburring will minimize potential damage to the forging die. A vibratory system can accommodate multislug deburring and with the proper speeds and media selections, the slugs become burr free and useable. The use of an automatic chamfering machine will effect a preferred deburred edge at slightly higher cost with the use of a double-ended flycutter technique with automatic load and unload mechanization.

4. Operation 3140 - Lubricate Slug

Equipment - Spray/dip line and heater, induction, 300 F, 200 kw, 400 Hz

Slugs subject to subsequent forming require surface lubricants in order to reduce the frictional forces and to maintain longer tool life. The lubrication process is preceded by heating the slugs to 300 F followed with a spray or dip using a water based colloidal graphite suspension.

5. Operation 3150 - Heat Slug

Equipment - Furnace, continuous tunnel, 850 F, 1350 lb/hr

Equipment alternatives
- Heater, induction, 300 kw, 400 hz
- Oil burners
- Gas burners

The slug is heated to 850 F in a continuous furnace preceding the forging operations. This step is necessary to reduce press capacity requirements for the alloy selected. It facilitates the forging processes.

6. Operation 3160 - Preform

Equipment - Press, mechanical, 400-ton, 20-inch stroke

The lubricated and heated slug is placed in the die and forged to the preform shape. This is the first of three steps in the hot forging operation.

Equipment - Press, mechanical, 1000-ton, 24-inch stroke

The lubricated and heated slug is placed in the first cavity of the press and preformed as the first hot forging step. It is immediately transferred to the second station in the same press for the forming step (Operation 3165) to achieve the final forged shape. The forging is immediately transferred to the third station in the same press for coining and piercing where the end of the ogive is formed and removed (Operation 3170). All three steps must be done in minimum time to prevent excessive heat loss. Forging can be accomplished in all three stations simultaneously to achieve maximum productivity on the press.

7. Operation 3165 - Form

Equipment - Press, mechanical, 400-ton, 24-inch stroke

The heated preform from Operation 3160 is the starting material for this operation. If the preform is cooled before the forming step is accomplished, cleaning, lubrication, and heating will be required prior to forming. The preform is placed in the die and formed in one stroke.

8. Operation 3170 - Coin and Pierce

Equipment - Press, mechanical, 400-ton, 24-inch stroke

The heated ogive from Operation 3165 is the starting material for this operation. If the ogive is cooled before the coin and pierce operation is accomplished, cleaning, lubrication, and heating will be required prior to coining and piercing. The ogive is placed in the die and coined and pierced in one stroke.

9. Operation 3180 - Clean

Equipment - Chemical line

The purpose of this operation is to remove lubrication and foreign materials from the forging.

10. Operation 3190 - Heat Treat

Equipment - Furnace, 900 F, 1200 lb/hr, quench tank, 150 F, aging oven, 250 F

The purpose of this process is to attain the required mechanical properties in the final part. The forged ogive is exposed to a 2-hour cycle at 900 F, quenched in water at 150 F, and aged for 28 hours at 250 F.

11. Operation 3195 - Finish Machine Outside Diameter & Face Rear Surface

Equipment - Lathe, multipass, single spindle automatic tracer, 8-inch swing, 24-inch centers, 25 hp

The above operation, finish machines the outer contour and faces the rear surface. It is accomplished by locating the ogive at the forward inside datum and driving with an internal expansion mandrel.

12. Operation 3200 - Finish Machine and Thread Nose

Equipment - Lathe, multipass, automatic chucking with threading attachment, 8-inch swing, 24-inch centers, 25 hp

The ogive is held at the large machined outside diameter and centered against the forward outside diameter. This operation is required to finish machine the nose cavity and cut the threads.

13. Operation 3210 - Finish and Thread Rear

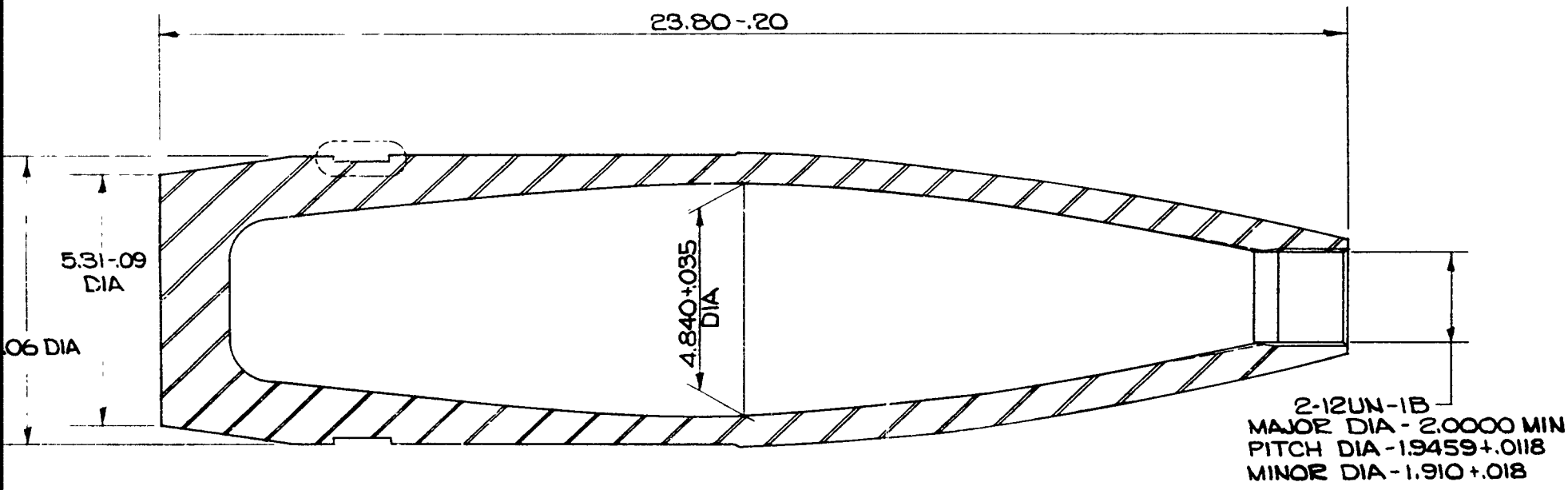
Equipment - Lathe, multipass, automatic tracing, 8-inch swing, 24-inch centers, 25 hp

In order to satisfy the closely held runout requirements between nose thread and outside profile, the ogive is held by the nose end and the large outside diameter for accurate centering. This operation completes the machining processes by thread chasing the large end thread and machining the O-ring seat.

14. Operation 3220 - Chromate Finish

Equipment - Chemical line

This final process removes foreign material and applies a protective chromate coating to improve paint adhesion in subsequent operations.



MATERIAL - HOT FORGE - CARBON STEEL, HOT ROLLED, SEMI-FINISHED FORGING QUALITY, NON RESULPHURIZED ASTM SPEC A273 (SECT 1-14 INCLUSIVE)

ALTERNATIVE MATERIAL - HOT CUP COLD DRAW - STEEL, FORGING, FOR SHELL STOCK, NON RESULPHURIZED SPEC MIL-S-10520
COLD EXTRUSION - STEEL BARS, CARBON, HOT ROLLED, FOR COLD SHAPING INCLUDING COLD EXTRUSION SPEC MIL-S-11310

FIGURE IV-1
BODY 155MM, M107
PART Nº 10535927

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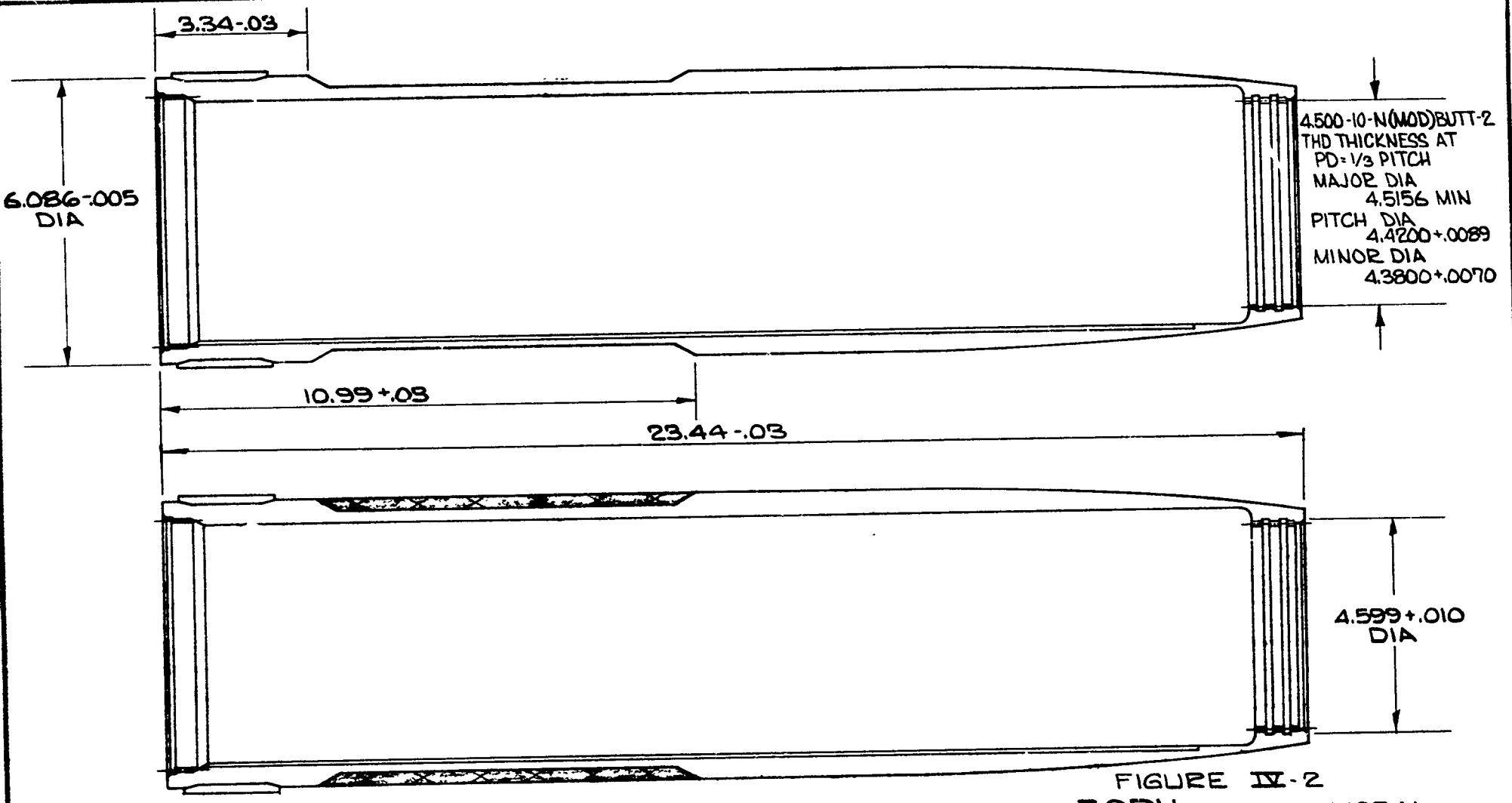

FIGURE IV-2

BODY 155MM, M483A1

PART Nº 10542912

MATERIAL BODY-STEEL, ALLOY, SEAMLESS, MECHANICAL TUBING, 4140 (ALT. 1340) SPEC ASTM A519

ALTERNATIVE MATERIAL - STEEL, ALLOY, BLOOMS, BILLETS AND SLABS FOR FORGING, 4140 (ALT. 1340) SPEC ASTM A274

STEEL, ALLOY, HOT ROLLED BARS, 4140 (ALT 1340) SPEC ASTM A274

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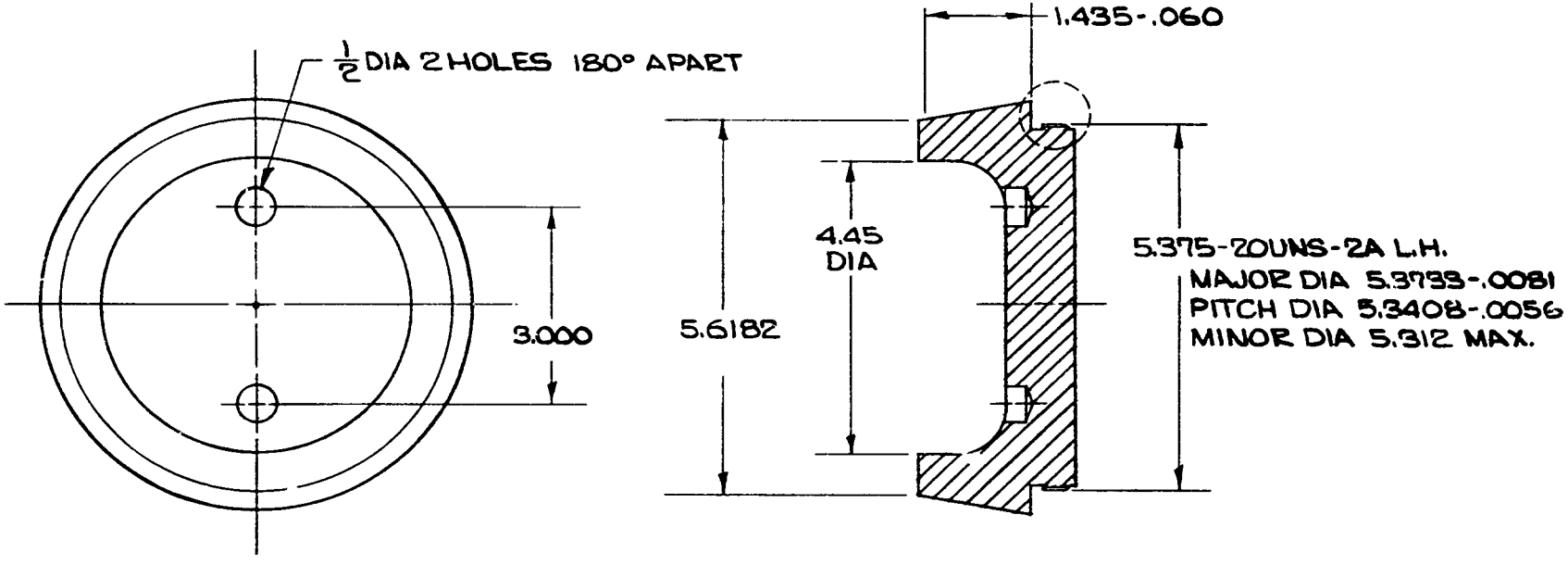

MATERIAL - ALUMINUM ALLOY 7075-T6 IMPACT EXTRUDED, SPEC MIL-A-12545. EXCEPT THAT THE MINIMUM ELONGATION SHELL BE 10% SPEC-MIL-P-50345 ALSO APPLIES.

FIGURE IV-3

BASE 155 MM, M483A1

PART Nº 10542904

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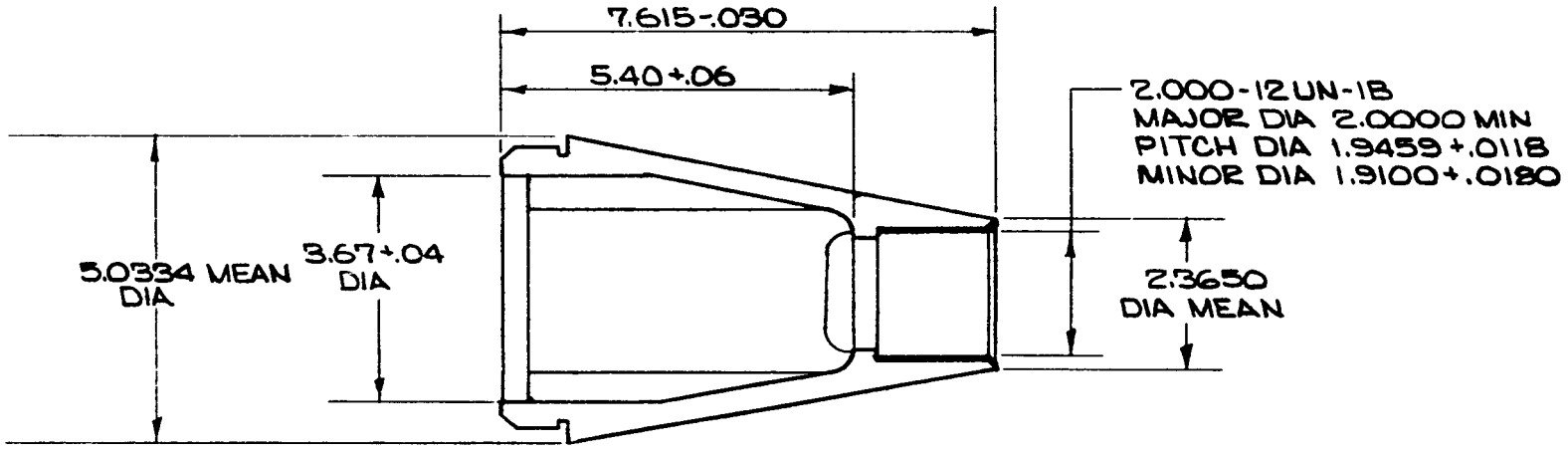

MATERIAL - ALUMINUM ALLOY SPEC. TO BE USED FOR SPECIFIC PROCESSES AS FOLLOWS-

MECHINE FROM ROD- SPEC ASTM B221
IMPACT EXTRUSION- SPEC ASTM B221
FORGING SPEC ASTM B247

FIGURE IV-4
OGIVE 155 MM, M483A1
PART Nº 10542916

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PLANT EQUIPMENT PACKAGE
MODERNIZATION PROGRAM

CASE, CART, M115B1, M148A1B1, M150B1 — 105 MM

Volume 4-1
Report No. 75-86-R-4-2
MODEL LINE DEVELOPMENT
CASE, CARTRIDGE, M115B1, M148A1B1, M150B1-105MM

prepared for
Project Manager
Munitions Production Base Modernization
and Expansion

administered by
Picatinny Arsenal
under Contract No. DAAA21-75-C-0303

April 1976

KAISER ENGINEERS
In Association with Stetter Associates, Inc.

TABLE OF CONTENTS

I. INTRODUCTION

The model line is a theoretical munitions production line related directly to the technical data package configuration and specifications. It is not intended to be a complete or sized production line that could be established in the future to produce a specified quantity of end item(s).

The model line is a benchmark made up of brief, but precise, technical information defining the production requirements of the particular end item, with process methods compatible with the proven state of the art in munitions production technology.

The model line will be the standard used by the PEP modernization team to review, analyze, and assess the active and inactive producers' capabilities to meet mobilization requirements. The model line documentation will include alternative process methods and technologies for the purpose of analysis, evaluation, and the recommendation of the most appropriate manufacturing system. Some processes within the line listed as alternatives are capable of producing the original item only and will not meet the requirements for the production of the replacement item. Again, these alternatives are included solely for a better evaluation of the current line.

The model line described in this report is for producing the following 105mm cartridge cases:

M148A1B1 for M456 HEAT & M490 TP
M115B1 for M392 APDS
M150B1 HEP for M393, HEP, M494 APERS & M416 WP

The model line developed is a composite of processes required to produce the above items. This composite line is the model line against which existing 105mm lines producing similar configurations will be evaluated.

The following sources of information were used in planning of the model line:

1. Reference Technical Package, 105MM Tank Ammunition Base, Manufacturing Technology Directorate, Frankford Arsenal.

2. Process Engineering Study, 105MM Steel Cartridge Case, Norris Industries, dated 21 September 1961.

3. 105MM M150B1 Cartridge Case Drawings, Ref. F, dated 1 November 1973; 105MM M148A1B1 Cartridge Case Drawings, Rev. E, dated 21 August 1973; 105MM M115B1 Cartridge Case Drawings, Rev. D, dated 12 November 1973; Munitions Development and Engineering Directorate and Product Assurance Directorate, Frankford Arsenal.

II. CHARACTERISTICS

Although the model line documentation lists sequential operations, it must be remembered that each operation may vary with respect to equipment used, completeness of operation performed, producer's labor skills, and the use of proprietary processes. The equipment may vary in that a mechanical press may be used instead of a hydraulic press, or a multispindle lathe may be used instead of an automatic, single-spindle lathe. Operations may vary because a producer may use single tooling and multiple presses instead of multiple tooling and a single press. Special processes used exclusively by a producer might combine sequential processes, etc.

Furnace capability is listed as a guide and may vary with producer processes, locale, and available energy source(s).

Machine tools are listed by type rather than by specific size or make. For example, a machine tool could be listed as a multispindle or an automatic chucker to indicate the type.

Chemical lines are not detailed as to dips, washes, rinses, etc., but are called standard lines. Dipping, spraying, etc. indicate the nature of the line (automatic-continuous, etc.) rather than the particular process.

Industrial plant equipment (IPE) is the base of the study. Other plant equipment (OPE) is discussed only where it is necessary to clearly identify the process requirements.

III. PROCESS DESCRIPTION SUMMARY

Following this page is the Process Description Summary, containing a sequence of operations required to manufacture this munition end product. Equipment used to perform each operation, including alternative machines (identified as EQ ALT) if applicable, are also listed. Multiple end items that may be produced on essentially the same line are indicated in the summary as well, and operations that apply to only one end item are designated as such.

The order in which the operations are performed is shown by the operation number. These are four-digit numbers with the first character designating the end item component and the balance indicating the numerical sequence of operations.

Opposite the operation number is a description of the operation with the equipment used listed below it. Under operation sequence, a path is shown by X's indicating steps of manufacture. If an alternative method of manufacture is available, it is shown by a branch from the main path. For a more detailed description of each operation, see Section IV, Analysis of Operations.

Gross capacities listed are estimated production capabilities of the equipment designated for the operation and are shown in pieces per hour. These figures are not factored for downtime or delays. As an example, a press that is capable of cycling in 10 seconds (i.e., 6 cycles per minute) will have a gross capacity of 360 pieces per hour.

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PROCESS DESCRIPTION SUMMARY
105MM CARTRIDGE CASE
PEP MODERNIZATION PROGRAM

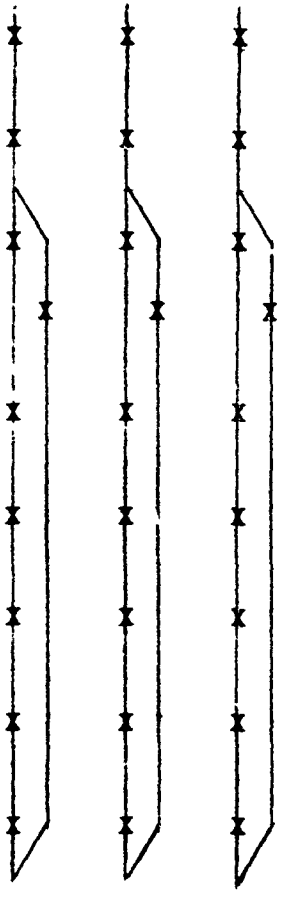
Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence M150	M148	M115
1110		Stamp Heat Code on Disc		X	X	X
	1	Stamping press, air cylinder	400			
	2	Stamping press, elec cylinder	400			
1120		Phosphate & Lubricate		X	X	X
	1	Chemical line	400			
1130		Form Cup		X	X	X
	1	Press, hydraulic-350 T	250			
	2	Press, mechanical-600 T	350			
1140		Clean		X	X	X
	1	Cleaning line	450			
1150		Anneal Cup		X	X	X
	1	Furnace, atmosphere, endothermic	300			
1160		Pickle, Phosphate & Lubricate		X	X	X
	1	Chemical line	300			
1170		First Draw		X	X	X
	1	Press, hydraulic-250 T	300			
1180		Clean		X	X	X
	1	Cleaning line	450			

PROCESS DESCRIPTION SUMMARY
105MM CARTRIDGE CASE
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr
1190		Anneal	
	1	Furnace, atmosphere, endothermic	
1200		Pickle, Phosphate & Lubricate	
	1	Chemical line	300
1210		Second Draw	
	1	Press, hydraulic-250 T	300
1210		Second & Third Draws	
	1	Press, hydraulic-400 T	300
1220		Trim Mouth	
	1	Press horn 1 inch	300
1230		Clean	
	1	Cleaning line	450
1240		Anneal	
	1	Furnace, atmospheric, endothermic	350
1250		Pickle, Phosphate & Lubricate	
	1	Chemical line	300
1260		Third Draw	
	1	Press, hydraulic-150 T	300

Operation Sequence



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PROCESS DESCRIPTION SUMMARY
105MM CARTRIDGE CASE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence M150 M148 M115
1270		Second Trim		
	1	Machine, rotary trim-1 1/2 hp	300	
1280		Prehead		
	1	Press, hydraulic-2000 T	300	
1290		Clean		
	1	Cleaning line	450	
1300		Anneal		
	1	Furnace, atmosphere, endothermic	350	
1310		Pickle, Phosphate & Lubricate		
	1	Chemical line	300	
1320		Fourth Draw		
	1	Press, hydraulic-200 T	300	
1330		Third Trim		
	1	Machine, rotary trim-1-1/2 hp	300	
1340		Final Head		
	1	Press, hydraulic-2500 T	300	
1350		Pierce Primer Hole		
	1	Press, mechanical-60 T	300	

PROCESS DESCRIPTION SUMMARY
105MM CARTRIDGE CASE
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

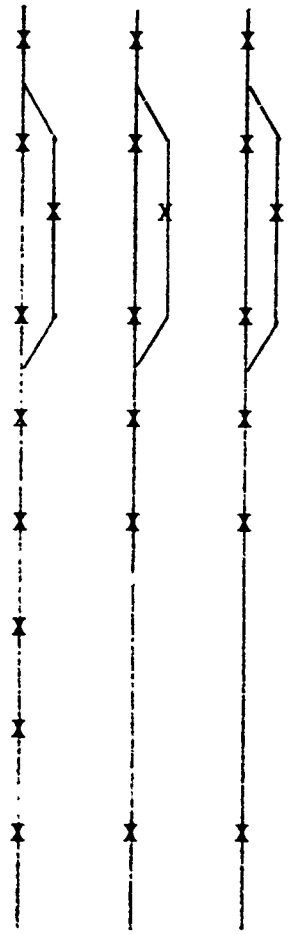
Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence M150	M148	M115
1360		Clean				
	1	Cleaning line	450			
1370		Heat Treat				
	1	Heater, induction-200 kw	300			
	2	Furnace, electric radiant-1750 F	300			
	3	Furnace, gas type-1750 F	300			
	4	Furnace, salt bath-1750 F	300			
1380		Retemper Taper				
	1	Furnace, coil induction-1000 F	300			
	2	Furnace, salt bath-1000 F	300			
1390		Pickle, Phosphate & Lubricate				
	1	Chemical line	300			
1400		Trim Mouth				
	1	Machine, rotary trim-1-1/2 hp	300			
1410		Bulge Test				
	1	Press, hydraulic-250 T	300			
1420		Taper Body				
	1	Press, hydraulic-75 T	300			

PROCESS DESCRIPTION SUMMARY
105MM CARTRIDGE CASE
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr
1430		Clean	
	1	Cleaning line	450
1440		Trim Mouth	
	1	Machine, rotary trim-1 hp	300
1440		Trim Mouth & Finish Machine Head	
	1	Lathe, multislide, single spindle	100
1450		Finish Machine Head	
	1	Lathe, multispindle-20 hp	100
1460		Thread Primer Hole	
	1	Machine, tapping-1-3/4 hp	90
1470		Clean	
	1	Cleaning line	450
1480		Retemper for Bead	
	1	Furnace, coil induction-1150 F	300
1490		Bead Roll	
	1	Machine, special roll & dies	200
1500		Retemper Mouth	
	1	Furnace, coil induction-1150 F	300
	2	Furnace, salt bath-1150 F	300

Operation Sequence



KAISER ENGINEERS

PROCESS DESCRIPTION SUMMARY
105MM CARTRIDGE CASE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence M150	M148	M115
1510		Size Mouth		X	X	X
	1	Press, mechanical-20 T	300			
1520		Stamp Identification		X	X	X
	1	Press, mechanical-30 T	300			
1530		Zinc Plate		X	X	X
	1	Plating line	300			
1540		Wax Coat			X	X
	1	Spray line & bake oven	300			

IV. ANALYSIS OF OPERATIONS

A. GENERAL

This description of 105mm steel cartridge case manufacture analyzes the cold draw, heat treat process. It is the primary process currently used in high volume production of these cases.

Raw stock is received in the form of steel discs and is easily handled using standard material handling techniques.

Process steps include:

- A sequential series of anneal, lubricate, draw, and trim steps to produce a basic case cylinder.
- A series of anneal, lubricate, form, and trim steps to form taper and neck.
- A series of anneal, lubricate, head, and pierce steps to produce base details.
- A heat treat step to obtain the required mechanical properties.
- A series of machining steps to produce final dimensions and configuration.

Considerable care must be exercised in the lubricate and clean steps. Contaminants, such as dirt or metal particles, may score both tooling and cases. Because of this, it is imperative that all burrs created during trimming operations be removed before further metal working.

The handling of cases during processing is important, particularly at the neck and taper areas. Nicks, checks, folds, or slivers are elongated in subsequent processing. Care must be exercised in softening the areas of the case for taper and neck forming and for machining. Only the specific areas to be further worked should be softened, since at this stage the case has been heat treated to achieve its final mechanical properties.

Dripping or tearing may occur after surface finishing. This usually happens when a dip process is used to apply wax. A detearing may be required for an acceptable final step.

B. OPERATIONS SEQUENCE

Material - Disc, carbon steel, AISI 1030, spheriodize annealed, 9.650-inch diameter x 0.690-inch thick, disc weight 14.2 lb

1. Operation 1110 - Stamp Heat Code on Disc

Equipment - Stamping press, automatic feed

Equipment alternative
- Air cylinder, line air pressure 90 psi
- Electric cylinder

This stamping operation identifies the heat code on the side of the blank for permanent traceability.

2. Operation 1120 - Phosphate and Lubricate

Equipment - Chemical line

Cold drawn parts subjected to subsequent cold working require proper surface preparation to prevent galling of the tooling. Conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

3. Operation 1130 - Form Cup

Equipment alternatives
- Press, hydraulic, 350-ton, 30-inch stroke
- Press, mechanical, 600-ton 30-inch stroke

This is the first forming operation to shape the blank (disc) into a cup.

4. Operation 1140 - Clean

Equipment - Cleaning line (system) chute or rotary type, spray/dip

This process removes impurities and the lubricant from the cup prior to annealing. If all lubricants are not removed, a hard scale deposit will form during annealing.

5. Operation 1150 - Anneal Cup

Equipment - Furnace, atmosphere, endothermic/carbon controlled, 1200 F, 5000 lb/hr

The cup undergoes subcritical annealing for approximately 40 minutes at 1200 F, facilitating further draws. The atmosphere-controlled environment minimizes scaling.

6. Operation 1160 - Pickle, Phosphate, and Lubricate

Equipment - Chemical line

Parts subjected to significant cold working require proper surface preparation to prevent galling of the tooling. Pickling and conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

7. Operation 1170 - First Draw

Equipment - Press, hydraulic, 250-ton, 30-inch stroke

This is the first draw in the process of reshaping the cup by cold working the sidewalls of the case.

8. Operation 1180 - Clean

Equipment - Cleaning line (system) chute or rotary type, spray/dip

This process removes impurities and the lubricant from the case. If all lubricants are not removed, a hard scale deposit will form during annealing.

9. Operation 1190 - Anneal

Equipment - Furnace, atmosphere, endothermic/carbon controlled, 1200 F, 5000 lb/hr

The case undergoes annealing for approximately 40 minutes at 1200 F, facilitating further draws. The atmosphere-controlled environment minimizes scaling.

10. Operation 1200 - Pickle, Phosphate, and Lubricate

Equipment - Chemical line

Parts subjected to significant cold working require proper surface preparation to prevent galling of the tooling. Pickling and conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

11. Operation 1210 - Second Draw

Equipment alternatives
- Press, hydraulic, 250-ton, 30-inch stroke
- Press, hydraulic, 400-ton 48-inch stroke

This operation further cold works the case walls, lengthening the case. If a 400-ton press is used, the second and third draws can be accomplished in one stroke of the press ram. The draw punch pulls the tubular shape through the second and third draw dies (mounted in tandem) in the die holder. If the second and third draws are performed in this manner, Operations 1220 thru 1260 can be eliminated.

12. Operation 1220 - Trim Mouth

Equipment - Horn press, 1-inch, 2 hp

Nibble trimming is used at this stage to remove excess material from the open end of the case.

13. Operation 1230 - Clean

Equipment - Cleaning line (system) chute or rotary type, spray/dip

This process removes impurities and the lubricant from the case prior to annealing. If all lubricants are not removed, a hard scale deposit will form during annealing.

14. Operation 1240 - Anneal

Equipment - Furnace, atmosphere, endothermic/carbon controlled, 1200 F, 5000 lb/hr

The case undergoes subcritical annealing for approximately 40 minutes at 1200 F facilitating further draws. The atmosphere-controlled environment minimizes scaling.

15. Operation 1250 - Pickle, Phosphate and Lubricate

Equipment - Chemical line

Parts subjected to significant cold working require proper surface preparation to prevent galling of the tooling. Pickling and conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

16. Operation 1260 - Third Draw

Equipment - Press, hydraulic, 150-ton, 36-inch stroke

The case is cold worked again and the sidewalls undergo further reduction, lengthening to approximately 14 inches.

17. Operation 1270 - Second Trim

Equipment - Rotary trim machine

The case is trimmed to remove excess material from the open end of the case.

18. Operation 1280 - Prehead

Equipment - Press, hydraulic, 2000-ton, 36-inch stroke

Preheading the case base gathers metal at the center of the head, facilitating the formation of metal for the primer boss and preforming the flange.

19. Operation 1290 - Clean

Equipment - Cleaning line (system) chute or rotary type, spray/dip

This process removes impurities and the lubricant from the case prior to annealing. If all lubricants are not removed, a hard scale deposit will form during annealing.

20. Operation 1300 - Anneal

Equipment - Furnace, atmosphere, endothermic/carbon controlled, 5000 lb/hr

The case undergoes annealing for approximately 40 minutes at 1200 F, facilitating further draws. The atmosphere-controlled environment minimizes scaling.

21. Operation 1310 - Pickle, Phosphate, and Lubricate

Equipment - Chemical line

Parts subjected to significant cold working require proper surface preparation to prevent galling of the tooling. Pickling and conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

22. Operation 1320 - Fourth Draw

Equipment - Press, hydraulic, 200-ton, 48-inch stroke

Final sidewall and length shaping operation to be followed by progressive sequential processes.

23. Operation 1330 - Third Trim

Equipment - Rotary trim machine, 1-1/2 hp

The case is trimmed for the third time to remove excess material from the open end of the case.

24. Operation 1340 - Final Head

Equipment - Press, hydraulic, 2500-ton, 36-inch stroke

The final heading operation forms the primer boss, the flange, and the internal head radius prior to machining operations.

25. Operation 1350 - Pierce Primer Hole

Equipment - Press, mechanical, 60-ton, 3-1/2-inch stroke

This operation rough pierces the primer hole subsequent to machining to size.

26. Operation 1360 - Clean

Equipment - Cleaning line (system) chute or rotary type, spray/dip

This process removes impurities and the lubricant from the cup prior to retempering. If all lubricants are not removed, a hard scale deposit will form during retempering.

27. Operation 1370 - Heat Treat

Equipment - Furnace, automatic, endothermic/carbon controlled 1750 F, 5000 lb/hr

Equipment alternatives
- Induction heater, 200 kw, 8000 Hz
- Electric radiant
- Gas type
- Salt bath

The mechanical properties of the case after cold working are achieved through austenitizing, quenching, and tempering heat treatment processes. Austenitizing is achieved at 1750 F for approximately 8 minutes, followed by spray or immersion in an agitated brine quench at 65 F. Tempering is done at 730 F for approximately 15 minutes.

28. Operation 1380 - Retemper Taper

Equipment - Furnace, coil induction, 1000 F, 100 kw, 8000 Hz
- Salt bath immersion

To taper the case mouth, it is necessary to retemper from 8 inches above the base to the mouth end, because during the heat treat, the part attains a hardness of Rc 32-38. This prohibits

any significent cold working deformation without further softening the affected sidewall by retempering at a higher temperature to Rb 90-95.

29. Operation 1390 - Pickle, Phosphate, and Lubricate

Equipment - Chemical line

Parts subjected to significant cold working require proper surface preparation to prevent galling of the tooling. Pickling and conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

30. Operation 1400 - Trim Mouth

Equipment - Rotary trim machine, 1-1/2 hp

This operation is performed to achieve premouth taper dimensional control.

31. Operation 1410 - Bulge Test

Equipment - Press, hydraulic, 250-ton, 36-inch stroke

The sidewall adjacent to the flange of the case is expanded to determine the integrity of the material structure.

32. Operation 1420 - Taper Body

Equipment - Press, hydraulic, 75-ton, 42-inch stroke

A taper is formed along the case sidewalls as depicted in Figure 1. Care must be exercised not to flute, wrinkle, collapse, or score the soft sidewalls.

33. Operation 1430 - Clean

Equipment - Cleaning line

Cleaning is required at this operation to remove the phosphate lubrication and to facilitate further processing.

34. Operation 1440 - Trim Mouth

Equipment alternatives
- Rotary trim machine, 1 hp
- Lathe, multislide, single-spindle, automatic tracer, 6-inch swing, 36-inch centers, 25 hp

The trim operation is performed to size the sidewall overall length preceding final machining of the base.

By using the multislide lathe, trimming the open end and finish machining of the head (except the tapping) can be combined, eliminating Operation 1450. Consolidating two setups into one reduces cost and improves quality.

35. Operation 1450 - Finish Machine Head

Equipment - Lathe, multispindle, automatic chucking, 36-inch centers, 20 hp

The primer hole is finish machined, and the flange outside diameter is turned and faced.

36. Operation 1460 - Thread Primer Hole

Equipment - Tapping machine, 1-3/4 hp

Standard machining operation.

37. Operation 1470 - Clean

Equipment - Cleaning line

Cleaning is required to remove cutting oils, chips, and other foreign materials prior to final mouth retempering. If all lubricants are not removed, a hard scale deposit will form during retempering.

38. Operation 1480 - Retemper For Bead, M150B1 Only

Equipment alternatives
- Furnace, coil induction 200 kw, 1150 F, 200 kw, 8000 Hz

34. Operation 1440 - Trim Mouth

Equipment alternatives
- Rotary trim machine, 1 hp
- Lathe, multislide, single-spindle, automatic tracer, 6-inch swing, 36-inch centers, 25 hp

The trim operation is performed to size the sidewall overall length preceding final machining of the base.

By using the multislide lathe, trimming the open end and finish machining of the head (except the tapping) can be combined, eliminating Operation 1450. Consolidating two setups into one reduces cost and improves quality.

35. Operation 1450 - Finish Machine Head

Equipment - Lathe, multispindle, automatic chucking, 36-inch centers, 20 hp

The primer hole is finish machined, and the flange outside diameter is turned and faced.

36. Operation 1460 - Thread Primer Hole

Equipment - Tapping machine, 1-3/4 hp

Standard machining operation.

37. Operation 1470 - Clean

Equipment - Cleaning line

Cleaning is required to remove cutting oils, chips. and other foreign materials prior to final mouth retempering. If all lubricants are not removed, a hard scale deposit will form during retempering.

38. Operation 1480 - Retemper For Bead, M150B1 Only

Equipment alternatives
- Furnace, coil induction 200 kw, 1150 F, 200 kw, 8000 Hz

This operation facilitates bead rolling on the M150B1. The sidewall ductility is increased to perform the cold working operation.

39. Operation 1490 - Bead Roll, M150B1 Only

Equipment - Special roll machine and dies

A 360-degree bead is rolled around the sidewall of the M150B1 at a point 1.90 inches from the open end, as shown in Figure 2.

40. Operation 1500 - Retemper Mouth

Equipment alternatives
- Furnace, coil induction 1150 F, 100 kw, 8000 Hz
- Furnace, salt bath immersion, 1150 F

This operation increases ductility of the tapered sidewall for mechanical coupling with the projectile.

41. Operation 1510 - Size Mouth

Equipment - Press, mechanical, 20-ton, 4-inch stroke

This operation resizes the forward section of the mouth with a plug to correct any out-of-round condition and expand the case mouth to specification requirement.

42. Operation 1520 - Stamp Identification

Equipment - Press, mechanical, 30-ton, 4-inch stroke

Nomenclature, date of manufacture, lot number, and contractor's identification are indented on the case.

43. Operation 1530 - Zinc Plate

Equipment - Plating line

The case is first cleaned and then zinc plated by the electro-deposition process with supplementary chromate coating. This is a protective coating required to prevent corrosion of the steel case.

44. Operation 1540 - Wax Coat, M148A1B1 and M115B1 Only

Equipment - Spray line and bake oven

Final process used only on cases M148A1B1 and M115B1. The specification calls for application of a uniform wax coat to the external surfaces and final bake.

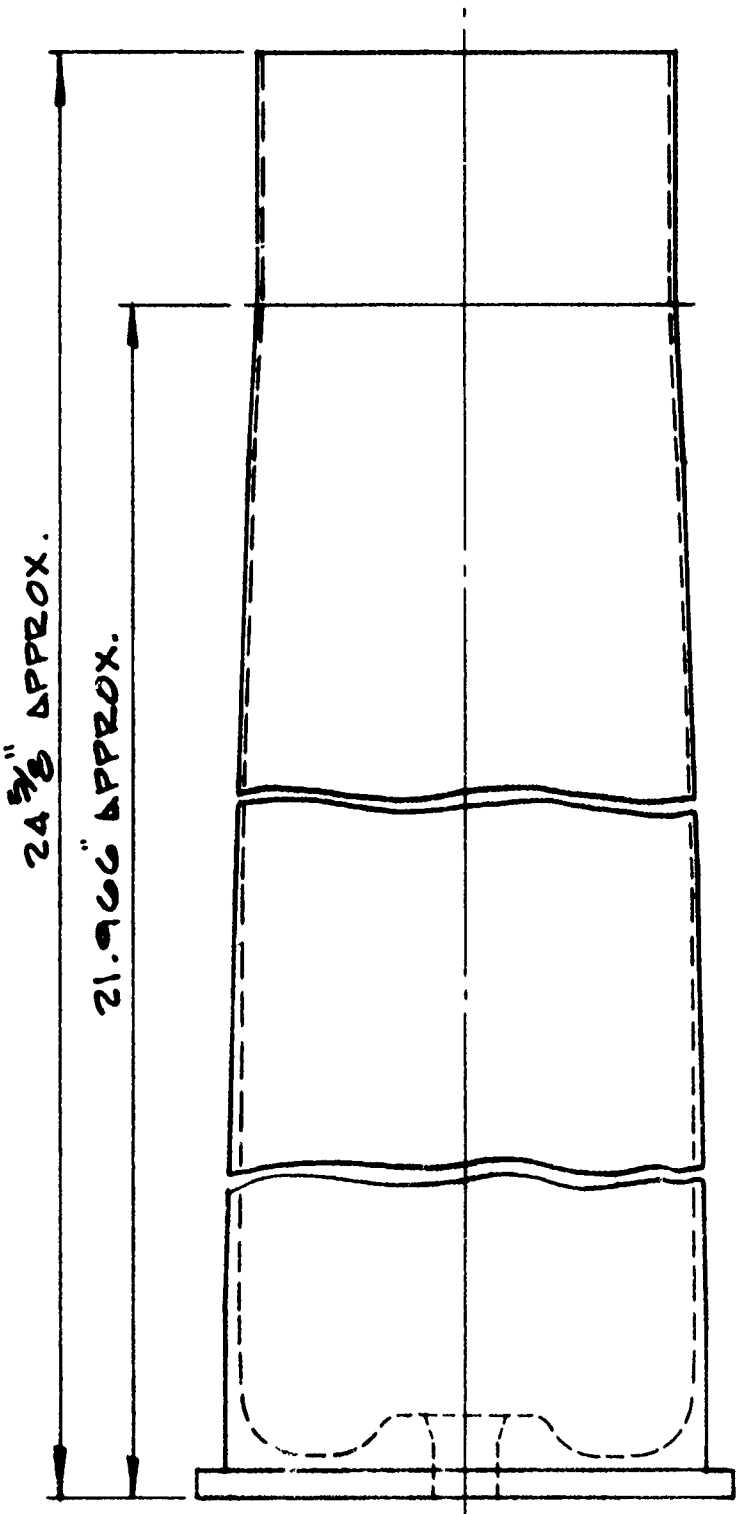


FIGURE 1

105 MM CARTRIDGE CASE TAPER

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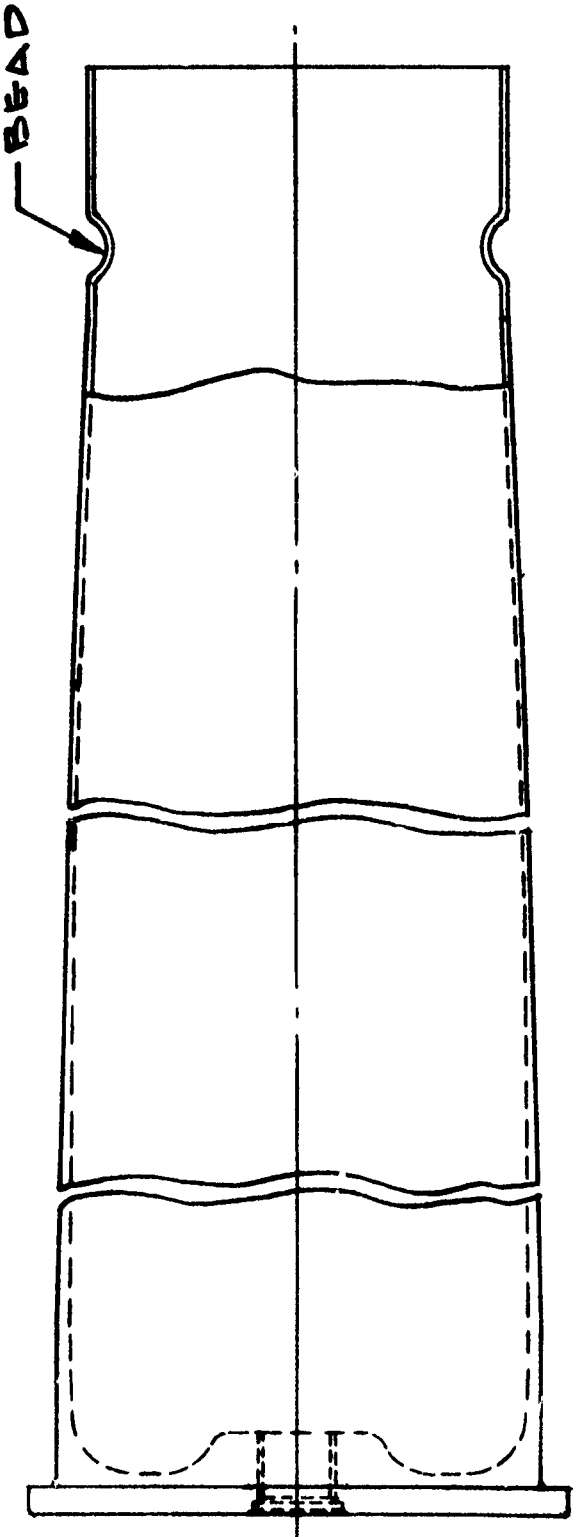

FIGURE 2

M 150 B1

105MM CARTRIDGE CASE

ROLL BEAD

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PLANT EQUIPMENT PACKAGE
MODERNIZATION PROGRAM

Volume 4-1
Report No. 75-86-R-4-3
MODEL LINE DEVELOPMENT
SHELL, HEAT-T, M456A1-105MM

prepared for
Project Manager
Munitions Production Base Modernization
and Expansion

SHELL, HEAT-T, M456A1 — 105 MM

administered by
Picatinny Arsenal
under Contract No. DAAA21-75-C-0303

April 1976

KAISER ENGINEERS
In Association with Stetter Associates, Inc.

TABLE OF CONTENTS

I. INTRODUCTION

The model line is a theoretical munitions production line related directly to the technical data package configuration and specifications. It is not intended to be a complete or sized production line that could be established in the future to produce a specified quantity of end item(s).

The model line is a benchmark made up of brief, but precise, technical information defining the production requirements of the particular end item, with process methods compatible with the proven state of the art in munitions production technology.

The model line will be the standard used by the PEP modernization team to review, analyze, and assess the active and inactive producers' capabilities to meet mobilization requirements. The model line documentation will include alternative process methods and technologies for the purpose of analysis, evaluation, and the recommendation of the most appropriate manufacturing system. Some processes within the line listed as alternatives are capable of producing the original item only and will not meet the requirements for the production of the replacement item. Again, these alternatives are included solely for a better evaluation of the current line.

The model line described in this report is for producing the 105MM Shell, HEAT-T, M456A1 (see Figures IV-1 thru IV-4).

The following sources of information were used in planning of the model line:

1. Reference Technical Package, 105MM Tank Ammunition Base, SARFA-MTE.

2. 105MM, HEAT M456A1, Projectile Metal Parts Drawings, Rev P, dated 730831, Munitions Development and Engineering Directorate and Product Assurance Directorate, Frankford Arsenal.

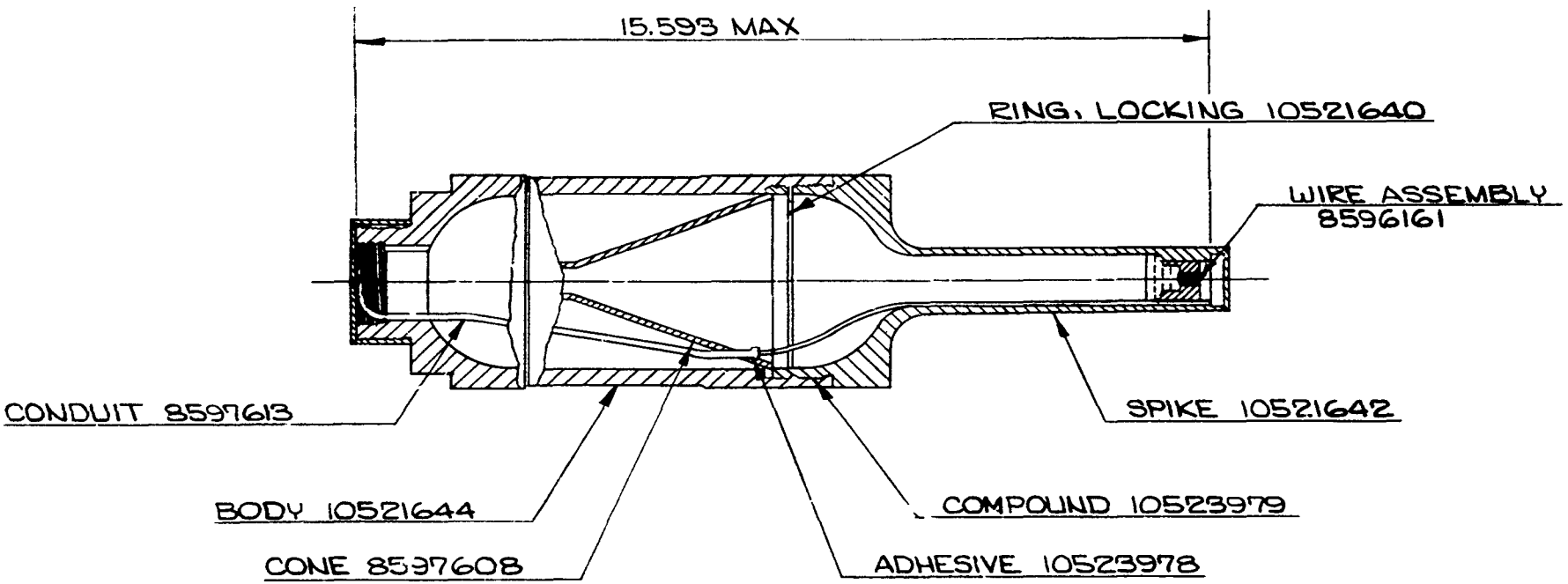

FIGURE I-1

PROJECTILE 105MM HEAT-T
M456A1 METAL PARTS

PART Nº 8597604

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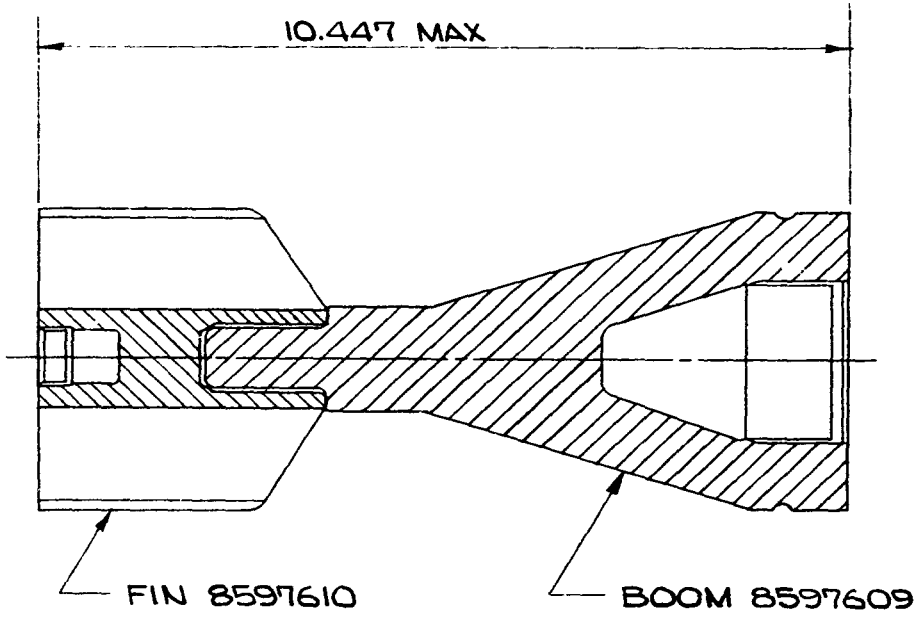
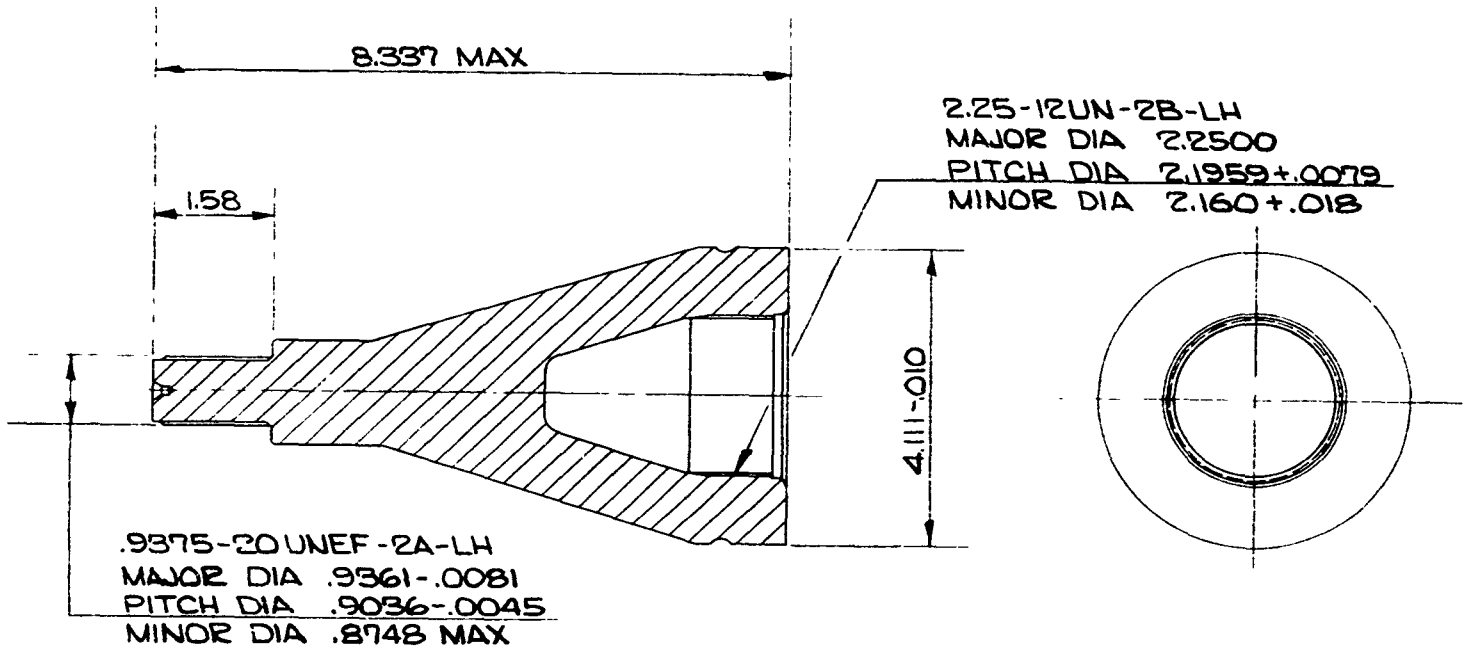


FIGURE I-2

FIN & BOOM ASSEMBLY
105MM. M456A1

PART Nº 8597611

KAISER ENGINEERS
OAKLAND, CALIFORNIA



MATERIAL - ALUMINUM ALLOY, ASTM SPEC B211 OR B221
ALTERNATIVE MATERIAL - ALUMINUM ALLOY FORGING
ASTM SPEC B247

FIGURE I-3

BOOM 105MM, M456A1
PART Nº 8597609

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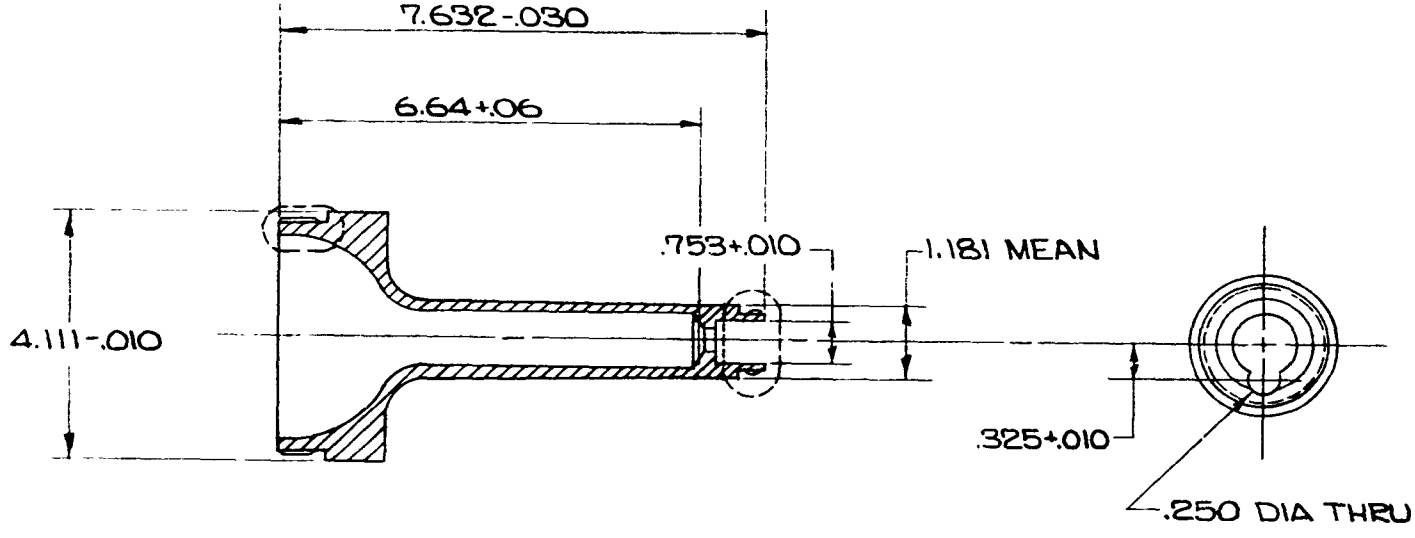

NOTE

MATERIAL - STEEL ALLOY, SEMIFINISHED, ASTM SPEC A274
(LEADED OR RESULPHURIZED STEEL NOT PERMITTED)

ALTERNATIVE MATERIAL - STEEL ALLOY BAR ASTM SPEC A322. STEEL, CARBON, BARS, HOT ROLLED, SPECIAL QUALITY, ASTM-A576
(LEADED OR RESULPHURIZED STEEL NOT PERMITTED)

FIGURE I-4

SPIKE 105MM, M456A1

PART NO. 10521642

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OAKLAND, CALIFORNIA

II. CHARACTERISTICS

The M456A1, 105MM shell contains 17 component parts, some of which can be produced using standard machining methods. Others require special processes such as plastic molding and extrusion. This model line study contains descriptions of manufacture for the pieces that can be made using standard machine shop techniques and recommends the purchase of items requiring special capability.

Tables II-1 and II-2 provide listings of the items recommended for in-house manufacture and vendor purchase.

Although the model line documentation lists sequential operations, it must be remembered that each operation may vary with respect to equipment used, completeness of operation performed, producer's labor skills, and the use of proprietary processes. The equipment may vary in that a mechanical press may be used instead of a hydraulic press, or a multispindle lathe may be used instead of an automatic, single-spindle lathe. Operations may vary because a producer may use single tooling and multiple presses instead of multiple tooling and a single press. Special processes used exclusively by a producer might combine sequential processes, etc.

Furnace capability is listed as a guide and may vary with producer processes, locale, and available energy source(s).

Machine tools are listed by type rather than by specific size or make. For example, a machine tool could be listed as a multispindle or an automatic chucker to indicate the type.

Chemical lines are not detailed as to dips, washes, rinses, etc., but are called standard lines. Dipping, spraying, etc. indicate the nature of the line (automatic-continuous, etc.) rather than the particular process.

Industrial production equipment (IPE) is the base of the study. Other plant equipment (OPE) is discussed only where it is necessary to clearly identify the process requirements.

TABLE II-1
ITEMS FOR IN-HOUSE MANUFACTURE

SHELL, HEAT-T, M456A1-105MM

Part Number	Description	Reason
10521644	Projectile body	Produced by the hot forge, heat treat method due to high mechanical strength requirements.
10521642	Spike	Typical upset hot forging application, with cold size alternative. Fixturing throughout this proces. is important.
8597608	Cone	This item is difficult to process. Existing producers tend to treat their approach as proprietary. A shear form process is dictated by the metal structure requirements of specification MIL-P-60646.
8597609	Boom	Can be forged from bar stock and then finish machined. However, normal procedure is to purchase as forging and finish machine.
8597610	Fin	Starts as an extrusion and is processed as a standard screw machine operation. Caution is required to avoid possible damage of the fin while machining.
10521640	Locking ring	Not difficult to machine but does have a deburr problem.
8597488	Plug	Standard screw machine application, could probably be purchased as plug and disc assembly.

TABLE II-1 (Cont)

Part Number	Description	Reason
8595465	Disc	Typical punch press blanking operation, could be purchased as plug and disc assembly.
8597614	Plug fuze lock	Standard screw machine application. Shipped separately.
8597489	Plug & disc assembly	Bonding operation. Shipped separately.
8597611	Fin & boom assembly	Standard assembly methods.
8597604	Projectile metal parts assembly	Has one operation not normally encountered in metal parts assembly, a coining or ironing operation to the cone flange to provide proper seating.
	Cone & conduit assembly	Standard bonding operation.

TABLE II-2

ITEMS RECOMMENDED FOR PURCHASE
SHELL, HEAT-T, M456A1 - 105MM

Part Number	Description	Reason
10534394	Cap, body protector	Made from a plastic material requiring plastic molding capabilities.
8597495	Cap, protector	Made from a plastic material requiring plastic molding capabilities.
8594970	Wire, insulated	Nylon coated stainless steel wire requiring wire drawing and coating capabilities.
8595501	Eyelet, terminal	Commercially produced fastener.
8595502	Insulator, nose	Made from a plastic material requiring plastic molding capabilities.
8595500	Wire & eyelet assembly	Electromechanical assembly requiring special assembly and test capability.
8594967	Terminal wire	Source-controlled part. Must be supplied by the vendor indicated on the drawing.
8597613	Conduit	Plastic extrusion, requires plastic extruding capabilities.
8597612	Obturator	Made from a plastic material, requires plastic molding capabilities.

III. PROCESS DESCRIPTION SUMMARY

Following this page is the Process Description Summary, containing a sequence of operations required to manufacture this munition end product. Equipment used to perform each operation, including alternative machines (identified as EQ ALT) if applicable, are also listed. Multiple end items that may be produced on essentially the same line are indicated in the summary as well, and operations that apply to only one end item are designated as such.

The order in which the operations are performed is shown by the operation number. These are four-digit numbers with the first character designating the end item component and the balance indicating the numerical sequence of operations.

Opposite the operation number is a description of the operation with the equipment used listed below it. Under operation sequence, a path is shown by X's indicating steps of manufacture. If an alternative method of manufacture is available, it is shown by a branch from the main path. For a more detailed description of each operation, see Section IV, Analysis of Operations.

Gross capacities listed are estimated production capabilities of the equipment designated for the operation and are shown in pieces per hour. These figures are not factored for downtime or delays. As an example, a press that is capable of cycling in 10 seconds (i.e., 6 cycles per minute) will have a gross capacity of 360 pieces per hour.

The Process Description Summary shows the sequence of operations for two alternative machining and finishing processes. These are identified as alternatives A and B and are both current conventional manufacturing processes.

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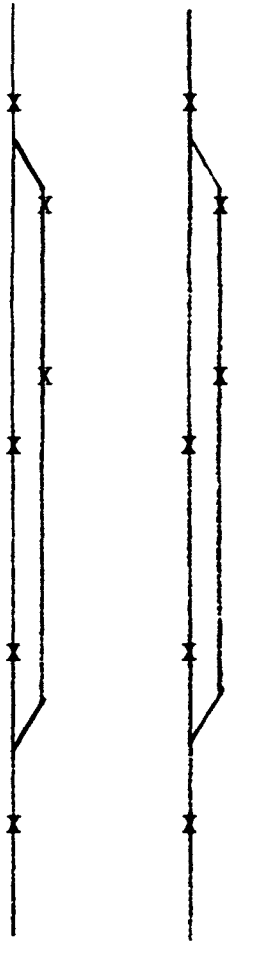
PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
********** PROJECTILE BODY (10521648) **********					
1110		Bar Handling			
	1	Transfer equipment, forklift	8		
1120		Heat Bar			
	1	Furnace, induction heater-1600 kw	8		
	2	Furnace, walking beam, gas-2200 F	8		
	3	Furnace, walking beam, oil-2200 F	8		
1130		Seperate Mults			
	1	Press-250 ton	180		
1130		Seperate Mults			
	1	Press-100 ton	500		
	2	Saw, circular-24 inch, 50 hp	120		
	3	Saw, band-16 inch, 25 hp	60		
	4	Press-200 ton & torch	200		
1140		Heat Mult			
	1	Furnace, induction heater-1600 kw	130		
	2	Furnace, rotary hearth kilns-2300 F	400		
	3	Furnace, salt bath-2300 F	130		
1150		Descale			
	1	Cabinet, water jet, auto feed	180		
	2	Sizing rolls-50 hp	180		



PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
1160		Cabbage & Pierce			
	1	Press, mechanical-1700 ton (for bar)	400		
	2	Press, hydraulic-350 ton (for tube)	200		
1170		Descale Outer & Inner Surface			
	1	Cabinet, shot blast-25 hp	125		
1180		Phosphate & Lubricate			
	1	Chemical line	200		
1190		Size Cavity			
	1	Press, hydraulic-250 ton	180		
1200		Heat Treat			
	1	Furnace, induction heater-1600 kw	200		
	2	Furnace, gas burner 1550-1650 F	200		
	3	Furnace, oil burner 1550-1650 F	200		
	1	Tempering quen-1100 F, 5000 lb/hr	200		
1210		Descale Cavity			
	1	Cabinet shot blast-25 hp	125		
1220		Hardness Test			
	1	Hardness tester	180		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
1230		Center Drill & Cutoff		X	X
	1	Lathe, auto chucking-15 hp	90		
1240		Rough Turn Outside Diameter & Rear End		X	X
	1	Lathe, auto chucking-15 hp	50		
1250		Finish Turn Outside Diameter		X	X
	1	Lathe, auto chucking tracer	47		
	2	Lathe, NC-20 hp	47		
1260		Grind Bourrelet		X	X
	1	Grinder, centerless-25 hp	120		
1270		Fin Rear End, Fuze Hole, Rough Face Surf B		X	X
	1	Lathe, auto chucking-40 hp	60		
1280		Broach Slots		X	X
	1	Broaching machine-10 hp	120		
1290		Machine 1-5/8-Inch, 16UN, LH Thread		X	X
	1	Tapping machine, auto-15 hp	120		
1300		Machine 2-1/4-Inch, 12UN, LH Thread & Fin Surf B		X	X
	1	Lathe, threading-20 hp	60		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEF MODERNIZATION PROGRAM

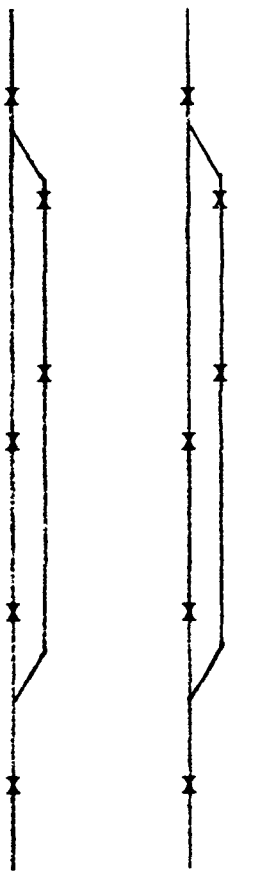
Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
1310		Machine 3-13/16-Inch, 20UNS, Thread & Fin Front			
	1	Lathe, threading-20 hp	52		
1320		Magnetic particle inspection			
	1	Special test equipment	120		
1330		Cadmium Plate			
	1	Chemical line	150		
1340		Buff Obturator Band Seat			
	1	Special buffing machine	140		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr
********** SPIKE (10521542) **********			
2110		Bar Handling	
	1	Transfer equipment/forklift	8
2120		Heat Bar	
	1	Furnace, induction heater-1800 kw	8
	2	Furnace, walking beam, gas-2200 F	8
	3	Furnace, walking beam, oil-2200 F	8
2130		Separate Mults	
	1	Press-250 ton	180
2130		Separate Mults	
	1	Press-800 ton	200
	2	Saw, circular-24 inch, 50 hp	100
	3	Saw, band-16 inch, 25 hp	80
2140		Heat Mult	
	1	Furnace, induction heater-1600 kw	150
	2	Furnace, rotary hearth kilns-2200 F	180
	3	Furnace, salt bath-2200 F	100
2150		Descale	
	1	Cabinet, water jet	180

Operation Sequence



PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
2160		Upset and Form		X	X
	1	Press, mechanical-400 ton	180		
	2	Press, hydraulic-200 ton	180		
2170		Cool		X	X
	1	Cooling tunnel	200		
2180		Descale		X	X
	1	Cabinet, shot blast, 25 hp	200		
2190		Coin			X
	1	Press, hydraulic-600 ton	240		
2200		Ream Inside Diameter of Stem			X
	1	Lathe, auto chucking-15 hp	60		
2210		Center Stem End		X	X
	1	Drill press, automatic	135		
2220		Rough Turn Outside Diameter		X	X
	1	Lathe, auto chucking-15 hp	48		
2230		Drill Stem & Rough Face Flange		X	X
	1	Lathe, auto chucking-8 spindle, 40 hp	43		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
2240		Rough Turn 1.7-Inch & 0.83-Inch Radii			
	1	Lathe, auto chucking-20 hp	30		
	2	Lathe, NC-20 hp	30		
2250		Heat Treat			
	1	Furnace, induction heater-1000 kw	150		
	2	Furnace, gas - 1550-1650 F	150		
	1	Furnace, tempering - 1550-1650 F	150		
2260		Hardness Test			
	1	Hardness tester	180		
2270		Turn Stem & 1.0625-Inch, UN Thread Flat, Fin Face Flange & 0.625-Inch Radius Blend			
	1	Lathe, auto chucking tracer	50		
	2	Lathe, NC-20 hp	50		
2280		Fin Turn Flange Outside Diameter & Thread Flat, Face Flange Base			
	1	Lathe, auto chucking-25 hp	64		
2290		Finish Turn 1.7-Inch & 0.83-Inch Radii			
	1	Lathe, auto chucking, tracer	43		
	2	Lathe, NC-20 hp	43		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
2300		Drill 0.5-Inch Diameter, Countr Bore Stem, Face		X	X
	1	Lathe, auto chucking-25 hp	57		
2310		Drill 0.25-Inch Diameter Hole		X	X
	1	Drill press, automatic	100		
2320		Ream 0.50-Inch Diameter Hole			X
	1	Drill press	120		
2330		Machine 3.8125-Inch, 20UNS Thread & Finish Face Surface C		X	X
	1	Lathe, threading	43		
2340		Machine 1.0625-Inch, 16UN Thread & Finish Face Surface D		X	X
	1	Lathe, threading	100		
2350		Phosphate Treat		X	X
	1	Chemical line	200		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
********** CONE (8597608) **********					
3110		Blank Disc and Form			
	1	Press, mechanical-50 ton	180		
3120		Shear Form			
	1	Machine, special shear forming	100		
3130		Deburr Nose			
	1	Machine, belt sanding	300		
3140		Extrude Spitback & Trim Flange			
	1	Press, mechanical-50 ton	200		
3150		Coin Taper & Flange			
	1	Press, mechanical-250 ton	200		
3160		Blank 3.756-Inch Diameter			
	1	Press, mechanical-50 ton	200		
3170		Machine Flange			
	1	Lathe, auto chucking-25 hp	120		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

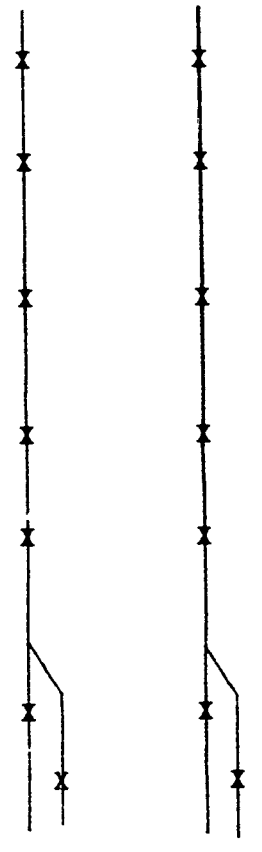
Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
3180		Drill 0.107-Inch Diameter Hole			
	1	Drill press, auto-1/2 hp	200		
3190		Deburr			
	1	Holding fixture & hand tools	50		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr
********** BOOM (8597609) **********			
4110		Bar Handling	
	1	Transfer equipment/forklift	8
4120		Seperate Slug	
	1	Saw, band-16 inch 25 hp	100
	2	Saw, circular-24 inch 50 hp	125
4130		Deburr Slug	
	1	Vibratory system	240
	2	Chamfering machine, auto-10 hp	240
4140		Lubricate Slug	
	1	Induction heater-200 kw & spray/dip line	240
4150		Heat Slug	
	1	Furnace, induction heater-500 kw	240
	2	Furnace, oil burners-850 F	240
	3	Furnace, gas burners-850 F	240
4160		Preform	
	1	Press, mechanical-400 ton	240
4160		Preform & Form	
	1	Press, mechanical-1000 ton	240

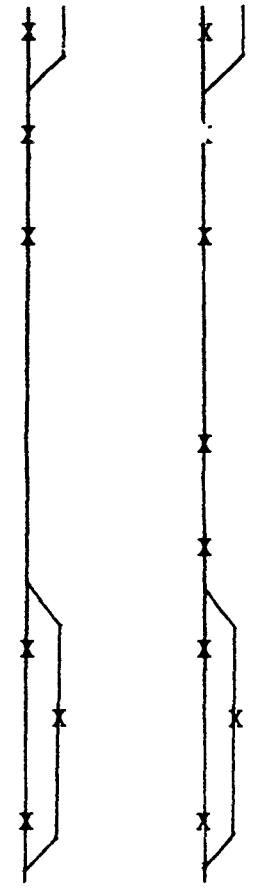
Operation Sequence



KAISER ENGINEERS

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
4170		Form			
	1	Press, mechanical-400 ton	240		
4180		Clean			
	1	Chemical line	200		
4190		Heat Treat			
	1	Furnace, induction heater-500 kw	240		
	2	Furnace, gas burners-900 F	240		
	3	Furnace, oil burners-900 F	240		
	1	Aging oven-250 F	240		
4200		Coin Center			
	1	Press, hydraulic-5 ton	300		
4210		Turn Taper & Face Front End			
	1	Lathe, auto chucking-15 hp	120		
4220		Finish Turn Small End			
	1	Lathe, auto chucking, multispindle-25 hp	150		
4220		Finish Turn Both Ends			
	1	Lathe, auto, 8-spindle-40 hp	150		
4230		Finish Turn Large End			
	1	Lathe, auto chucking-25 hp	75		



PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

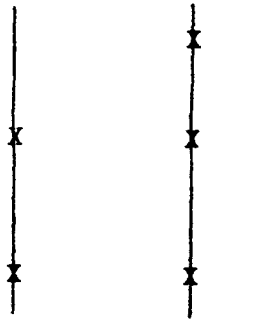
Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
4240		Deburr Large End			
	1	Holding fixture & hand tools	120		
4250		Anodize			
	1	Chemical line	200		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
********** FIN (8597610) **********					
5110		Extrusion Handling			
	1	Transfer equipment/forklift	4		
5120		Saw Mult			
	1	Abrasive saw--10 inch, 10 hp	240		
5130		Finish Turn Outside Diameter, Drill, Ream & Thread Tracer Cavity, Finish Face & Cutoff			
	1	Lathe, auto multispindle-50 hp	240		
5140		Finish Turn Angle, Drill, Ream, Face, Chamfer & Thread Front End			
	1	Lathe, auto chucking, 8-spindle-40 hp	120		
5150		Mill 30-Degree Angle			
	1	Machine, boring, auto-3 hp	240		
5160		Finish Front End, Rough Turn Large Diameter			
	1	Lathe, auto chucking, multispindle-30 hp	240		
5170		Finish Turn Outside Diameter			
	1	Machine, boring auto, dual spindle-3 hp	300		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
5180		Finish Turn Rear End			
	1	Lathe, auto chucki. , multispindle-30 hp	240		
5190		Deburr			
	1	Machine, deburr-5 hp	240		
	2	Vibratory system-15 hp	200		
5200		Clean & Anodize			
	1	Chemical line	200		



PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
********** LOCKING RING (10521640) **********					
6110		Bar Handling			
	1	Transfer equipment, forklift	8		
6120		Finish Turn & Machine 3.8125-Inch, 20UNS Threads			
	1	Lathe, auto multispindle bar-40 hp	150		
	2	Lathe, auto chucking (bar)-20 hp	50		
6130		Mill Slots			
	1	Drill press, auto-5 hp	128		
6140		Phosphate Treat			
	1	Chemical line	200		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
********** PLUG (8597488) **********					
7110		Rod Handling		X	X
	1	Transfer equipment/forklift	8		
7120		Machine, Thread & Cut Off Plug		X	X
	1	Lathe, multispindle-15 hp	240		
	2	Lathe, auto chucking (bar)-10 hp	60		
7130		Drill Spanner Holes	-	X	X
	1	Drill, multispindle-5 hp	120		
	2	Drill, multispindle head	120		
7140		Deburr		X	X
	1	Vibratory system-10 hp	500		
7150		Anodize		X	X
	1	Chemical line	200		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
********** DISC (8595465) **********					
8110		Coil Handling			
	1	Forklift	2		
	2	Crane/hoist	2		
8120		Blank			
	1	Press, mechanical-10ton	500		

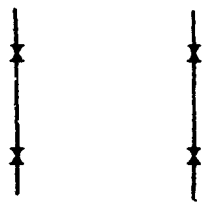
PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	 Alt B
********** PLUG & DISC ASSEMBLY (8597489) **********					
9110		Bond Disc to Plug			
	1	Auto fixture & applicator	180		
9120		Crimp 360 Degrees			
	1	Crimping fixture, air-90 psi	300		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
********** FIN & BOOM ASSEMBLY (8597611) **********					
10110		Apply Adhesive			
	1	Adhesive applicator	120		
10120		Assemble Fin & Boom			
	1	Holding fixture & torque wrench	120		



PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
********** CONE & CONDUIT ASSEMBLY **********					
11110		Clean			
	1	Cleaning line	200		
11120		Assemble & Apply Adhesive			
	1	Auto fixturing & adhesive applicator	180		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
********** PROJECTILE METAL PARTS ASSEMBLY (8597604) **********					
12110		Seat Cone & Conduit Assembly in Body			
	1	Press, hydraulic-50 ton	180		
12120		Apply Thread Compound			
	1	Fixture & sealant compound applicator	180		
12130		Install Locking Ring			
	1	Holding & torque fixture	180		
12140		Air Test			
	1	Special airleak test fixture	180		
12150		Apply Thread Compound			
	1	Fixture & applicator	180		
12160		Assemble Wire to Spike			
	1	Bench	180		
12170		Feed Wire Thru Conduit & Preasmbl Spike			
	1	Bench	180		
12180		Apply Compound to Body Threads			
	1	Bench	180		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Operation Sequence Alt B
12190		Torque Spike to Body			
	1	Torque wrench & fixture	180		
12200		Align Wire & Seat in Slot			
	1	Bench	180		
12210		Assemble, Terminal to Wire			
	1	Bench, hypo needle, hand crimping tool	180		
12220		Stamp Identification			
	1	Rotary stamping machine	300		

PROCESS DESCRIPTION SUMMARY
SHELL, HEAT-T, M456A1 - 105MM
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operation Sequence Alt A	Alt B
********** PLUG, FUZE LOCK (8597614) **********					
13110		Bar Handling			
	1	Transfer equipment/forklift	4		
13120		Bore Cavity, Turn Thread & Cut Off			
	1	Lathe, auto multispindle bar-30 hp	180		
	2	Lathe, auto chucking (bar)-15 hp	60		
13130		Drill Spanner Holes			
	1	Drill, multispindle-5 hp	120		
	2	Drill, multispindle head	120		
13140		Deburr			
	1	Vibratory system-10 hp	500		
13150		Cadmium/Zinc Plate			
	1	Chemical line	200		

IV. ANALYSIS OF OPERATIONS

A. PROJECTILE BODY (10521644)

Material - Steel, bar, alloy, hot rolled, nonresulfurized, 4-1/4-inch diameter, bar weight 1020 lb
- Steel, tubing, seamless, mechanical, nonresulfurized, 4-1/2-inch OD x 3-1/4-inch ID, tube weight 517 lb

1. Operation 1110 - Bar Handling

Equipment - Transfer equipment
- Sorting table
- Forklift and standard cranes

The steel bar is transported in bundles to a sorting table where it is unbanded and sorted for receiving inspection and sampling. It is then positioned for transfer to the area where the mults are separated.

2. Operation 1120 - Heat Bar (for Hot Shearing only)

Equipment - Furnace, continuous tunnel, 2200 F, 100 lb/min

Equipment alternatives
- Induction heater, 1600 kw, 400 Hz
- Walking beam, gas
- Walking beams, oil

Heating is used in conjunction with hot shearing only. The bar is fed continuously through the tunnel, exiting at the desired temperature. Overtemperature controls are required to handle line stoppage problems.

3. Operation 1130 - Separate Mults

Equipment alternatives
- Press, 250-ton (hot shearing)
- Press, 1000-ton (cold shearing)
- Carbide tipped circular saw, 24-inch, 50 hp
- Band saw, 16-inch, 25 hp
- 200-ton press and torch (nick and break)

Mults must be weighed after cutting with each process. Tubing can be separated only by cutting.

a. Hot Shear

A 250-ton shear press requires automatic feed, clamp, and eject attachments. The press should be part of the production line so the hot mult can be processed through descale, cabbage, and pierce without further heating.

b. Cold Shear

The 1000-ton shear press requires automatic feed, clamp, and eject attachments. The press may be in the production line to minimize material handling and traceability problems, but can be offline if facilities dictate.

c. Circular Saw

Carbide tipped circular saws offer the most precision in the generation of mults.

d. Band Saw

The band saw is less accurate but less expensive than a circular saw. The band sawing process is slow compared to forging, requiring multiple band saws.

e. Nick and Break

This process is based on the placement of a stress concentration in the cold bar, called the nick, followed by a cold breaking operation.

A 200-ton press is required as well as a good holddown system in order to break the bar. This operation is not as accurate as shearing, but requires less capital investment and lower cost tooling.

f. Flame Cutting

Flame cutting is not recommended because it is slow, wasteful, and may affect the metallurgy of the bar.

g. Abrasive Cutting

Abrasive cutting, even wet, is not approved. Experience has shown that trapped abrasive causes excessive tool wear during forging.

4. Operation 1140 - Heat Mult

Equipment - Furnace, continuous tunnel, 2300 F, 100 lb/min

Equipment alternatives
- Induction heater, 1600 kw, 400 Hz
- Rotary hearth kilns
- Salt bath

This step is required prior to hot forging. Time at temperature should be long enough to assure uniform heating, but excessive soak time should be avoided due to the high rate of scaling.

5. Operation 1150 - Descale

Equipment alternatives
- Cabinet, water jet automatic feed
- Sizing rolls, 50 hp

a. Removal of scale from hot mults prior to forging is accomplished by water jets. Water pressures of 1200 to 2200 psi and flow rates of 1/2 to 2 gallons per second are normally used. Power feeding of the hot mults is by chain conveyor or pusher.

b. An alternative method for removing scale is to mechanically crack the scale with rolls, dies, etc. This process is not commonly used.

6. Operation 1160 - Cabbage and Pierce

Equipment alternatives
- Press, 1700-ton, mechanical, 48-inch stroke for RCS bar stock
- Press, 350-ton, hydraulic, 48-inch stroke for tubular stock

The cabbage step causes the heated square mult to assume the shape of the round die. Once sized, the first major movement of metal is accomplished, with or without reheat, in the pierce step. The uniformity of metal flow determines the effectiveness of the succeeding operations and overall dimensional accuracy and level of quality.

The cabbage and pierce step is replaced by an upset step if tubular stock is used. The upset step is a hot working process that transforms the tube mult into the equivalent of the hot forged shape.

7. Operation 1170 - Descale Outer and Inner Surface

Equipment - Cabinet, shot blast, automatic feed, 25 hp

Removal of scale from the forged surface of the forging is accomplished by steel shot propelled at high velocity. The forging is rotated in a vertical position for total exposure to shot blast.

8. Operation 1180 - Phosphate and Lubricate

Equipment - Chemical line

Forgings subject to subsequent cold work require proper surface preparation to prevent galling of the tooling. Conversion coats of the phosphate type are used universally to provide a base for the lubricant. Modern lubricants include soaps, graphite, and molybdenum disulfide dispersions and chlorinated, high viscosity oils.

9. Operation 1190 - Size Cavity

Equipment - Press, 250-ton, hydraulic, 36-inch stroke

This process shapes the cavity to final size.

10. Operation 1200 - Heat Treat

Equipment - Furnace, continuous, 1550-1650 F
- Tempering furnace, 1100 F, 5000 lbs/hr

Equipment alternatives

- Induction, 1600 kw, 400 Hz
- Gas burners
- Oil burners

The mechanical properties of the shell body are achieved through austenitizing, quenching, and tempering heat treatment. Furnace or induction heating is used to austenitize at 1550 to 1650 F. Quenching should be by spray, or immersion in an agitated bath. Tempering is accomplished in a standard, lower temperature oven.

11. Operation 1210 - Descale Cavity

Equipment - Cabinet, shot blast, automatic feed, 25 hp

Removal of heat treat scale from the cavity of the shell body is accomplished by steel shot propelled at high velocity. The shell body is rotated in a vertical position for total exposure to the shot blast.

12. Operation 1220 - Hardness Test

Equipment - Hardness tester

Each heat treated body is subjected to a hardness test. After harness testing, one of the hardest and one of the softest are selected for tension test specimens to ascertain mechanical properties of the heat treat lot.

13. Operation 1230 - Center Drill and Cutoff

Equipment - Lathe, automatic chucking, 6-inch swing, 36-inch centers, 15 hp

This operation provides the center for subsequent turning operations.

14. Operation 1240 - Rough Turn Outside Diameter and Rear End

Equipment - Lathe, automatic chucking, 6-inch swing, 36-inch centers, 15 hp

The forging is chucked by an internally expanding mandrel. The base end of the forging is supported by a live tailstock center.

The outside diameter is turned to remove forged surfaces, eccentricities, and prepare the blank for further processing.

15. Operation 1250 - Finish Turn Outside Diameter

Equipment alternatives
- Lathe, automatic chucking, tracer
- Lathe, numerical control, 6-inch swing, 36-inch centers, 20 hp

Standard machining operation.

16. Operation 1260 - Grind Bourrelet

Equipment - Centerless grinder, automatic feed, 25 hp

Grinding is required only if the required finish cannot be produced during the previous turning operation.

17. Operation 1270 - Finish Rear End, Fuze Hole, and Rough Face Surface "B"

Equipment - Lathe, automatic chucking, 6-spindle, 8-inch swing, 40 hp

Standard machining operation.

18. Operation 1280 - Broach Slots

Fquipment - Broaching machine, vertical, 10 hp

Two slots, 180 degrees apart, are broached for passage of the terminal wire during succeeding assembly operations.

19. Operation 1290 - Machine 1-5/8-Inch 16UN LH Thread

Equipment - Machine, tapping, automatic, 15 hp

Standard tapping operation.

20. Operation 1300 - Machine 2-1/4-Inch 12UN LH Thread and Finish Face Surface "B"

Equipment - Lathe, threading, 20 hp

Relationship between threads and shoulder must be closely controlled to minimize runout at assembly.

21. Operation 1310 - Machine 3-13/16-Inch 20UNS Thread and Finish Face Front End

Equipment - Lathe, threading, 20 hp

The relationship between threads and front face must be closely controlled to minimize runout at assembly.

22. Operation 1320 - Magnetic Particle Inspection

Equipment - Special test equipment

The body is magnetized, then covered with a solution that contains fine magnetic particles held in suspension. A black light is directed at the surfaces of the body for the detection of particle patterns. The body is then demagnetized in a reversing magnetic field.

23. Operation 1330 - Cadmium Plate

Equipment - Chemical line

The finish machined body is processed through multistage cleaning, etching, and electroplating with supplementary phosphate coating.

24. Operation 1340 - Buff Obturator Band Seat

Equipment - Machine, buffing, special

The band seat is buffed to remove the phosphate coating to facilitate succeeding assembly operations.

B. SPIKE (10521642)

Material - Steel, alloy, hot rolled, nonresulfurized, 1-3/4-inch diameter, bar weight 164 lb

1. Operation 2110 - Bar Handling

Equipment - Transfer equipment
- Sorting table
- Standard cranes
- Forklift

The steel bar is transported in bundles to a sorting table where it is unbanded and sorted for receiving inspection and sampling. It is then positioned for transfer to the area where the mults are separated.

2. Operation 2120 - Heat Bar (for Hot Shearing only)

Equipment - Furnace, continuous tunnel, 2200 F, 100 lb/min

Equipment alternatives
- Induction heater, 1800 kw 400 Hz
- Walking beam, gas
- Walking beam, oil

Heating is used in conjunction with hot shearing only. The bar is fed continuously through the tunnel, exiting at the desired temperature prior to shearing. Overtemperature controls are required to handle line stoppage problems. Heating is not required if mult separation is done by cold shearing or sawing.

3. Operation 2130 - Separate Mults

Equipment alternatives
- Press, 250-ton, (hot shearing)
- Press, 800-ton, (cold shearing)
- Carbide tipped circular saw, 24-inch, 50 hp
- Band saw, 16-inch, 25 hp

Mults must be weighed after cutting with each process.

a. Hot Shear

A 250-ton shear press requires automatic feed, clamp, and eject attachments. The press should be part of the production line, so the hot mult can be processed through descale and upset and formed without further heating.

b. Cold Shear

The 800-ton shear press requires automatic feed, clamp, and eject attachments. The press may be in the production line to minimize material handling and traceability problems, but can be offline if facilities dictate.

c. Circular Saw

Carbide tipped circular saws cut precision mults.

d. Band Saw

The band saw is less accurate but less expensive than a circular saw. The band sawing process is slow compared to forging requiring multiple band saws.

e. Flame Cutting

Flame cutting is not recommended because it is slow, wasteful of material and may affect the metallurgy of the mult.

f. Abrasive Cutting

Abrasive cutting, even wet, is not approved. Experience has shown that trapped abrasive causes excessive tool wear during forging.

4. Operation 2140 - Heat Mult

Equipment - Furnace, continuous tunnel, 2200 F, 100 lb/min

Equipment alternatives
- Induction heater, 1600 kw, 400 Hz
- Rotary hearth kilns
- Salt bath furnaces

This step is required prior to hot forging. Time at temperature should be long enough to assure uniform heating, but excessive soak time should be avoided due to the high rate of scaling.

5. Operation 2150 - Descale

Equipment - Cabinet, water jet automatic feed

Removal of scale from hot mults prior to forging is accomplished by water jets. Water pressures of 1200 to 2200 psi and flow rates of 1/2 to 2 gallons per second are normally used. Power feeding of the hot mults is by chain conveyor or pusher.

6. Operation 2160 - Upset and Form

Equipment alternatives
- Press, mechanical, 400-ton, 36-inch stroke
- Press, hydraulic, 200-ton, 36-inch stroke

The upset step causes the heated mult to assume the shape of the die. Once sized, the first major movement of metal is accomplished, with or without reheat, in the form step. The concentricity and uniformity of metal flow during this step determines the effectiveness of the subsequent operations and the overall level of quality.

7. Operation 2170 - Cool

Equipment - Tunnel, cooling

Alloy steels have mechanical properties that are sensitive to cooling rates from forging temperatures. To produce the best possible metallurgical structure for subsequent machining operations, the cooling environment must be slow. Also, slower cooling introduces fewer thermal stresses and less warpage.

8. Operation 2180 - Descale

Equipment - Cabinet, shot blast, 25 hp

Removal of scale from the outer surfaces of the forging is accomplished by steel shot propelled at high velocity. The forging must be rotated to expose all surfaces to the shot blast.

9. Operation 2190 - Coin

Equipment - Press, hydraulic, 600-ton, 24 inch stroke

The bell section of the flange end is coined to produce a more uniform contour for subsequent machining operations.

10. Operation 2200 - Ream Inside Diameter of Stem

Equipment - Lathe, automatic chucking, 6-inch swing, 24-inch centers, 15 hp

The cavity of the stem is reamed to finish size.

11. Operation 2210 - Center Stem End

Equipment - Drill press, automatic with shuttle table

This operation provides the center for subsequent turning operations after hot forging.

12. Operation 2220 - Rough Turn Outside Diameter

Equipment - Lathe, automatic chucking, 6-inch swing, 36-inch centers, 15 hp

The forging is chucked internally with location to the datum surface. The stem end of the forging is supported by a live tailstock center. The outside diameter is turned to remove forged surfaces and eccentricities.

13. Operation 2230 - Drill Stem and Rough Face Flange

Equipment - Lathe, automatic chucking 8-spindle, 6-inch swing, 40 hp

The stem is drilled to various depths in the multistations of the lathe to minimize the cycle time of the operation.

14. Operation 2240 - Rough Turn 1.7-Inch and 0.83-Inch Radii

Equipment alternatives

- Lathe, automatic chucking, tracer, 20 hp
- Lathe, numerical control, 6-inch swing, 36-inch centers, 20 hp

14. Operation 2240 - Rough Turn 1.7-Inch and 0.83-Inch Radii

Equipment alternatives
- Lathe, automatic chucking, tracer, 20 hp
- Lathe, numerical control, 6-inch swing, 36-inch centers, 20 hp

The flange surfaces are turned to remove forged surfaces and irregularities before further processing.

15. Operation 2250 - Heat Treat

Equipment - Furnace, 1550 - 1650 F
- Tempering furnace

Equipment alternatives
- Furnace, induction, 1000 kw, 400 Hz
- Furnace, gas

The strength of the spike after hot forging is achieved with an austenitizing, quenching, and tempering heat treatment. Furnace or induction heating is used to austenitize at 1550 to 1650 F. Quenching should be by spray or immersion in an agitated bath. Tempering is accomplished in a standard, lower temperature oven.

16. Operation 2260 - Hardness Test

Equipment - Hardness tester

Each spike is subjected to a hardness test. After hardness testing, one of the hardest and one of the softest are selected for tension test specimens to ascertain mechanical properties of the heat treat lot.

17. Operation 2270 - Finish Turn Stem and 1.0625-Inch 16UN Thread Flat, Finish Face Flange and 0.625-Inch Radius Blend

Equipment alternatives
- Lathe, automatic chucking, tracer
- Lathe, numerical control, 6-inch swing, 36-inch centers, 20 hp

Standard machining operation.

18. Operation 2280 - Finish Turn Flange Outside Diameter and Thread Flat, Face Flange Base

Equipment - Lathe, automatic chucking, multispindle, five-inch swing, 25 hp

Standard machining operation.

19. Operation 2290 - Finish Turn 1.7-Inch and 0.83-Inch Radii

Equipment alternatives
- Lathe, automatic chucking, tracer
- Lathe, numerical control, 6-inch swing, 36-inch centers, 20 hp

Standard machining operation.

20. Operation 2300 - Drill 0.5-Inch Diameter, Counter Bore Stem End, Face

Equipment - Lathe, automatic chucking, multispindle, 5-inch swing, 25 hp

Standard machining operation.

21. Operation 2310 - Drill 0.25-Inch Diameter Hole

Equipment - Drill press, automatic with shuttle table

The spike is positioned and held by a fixture for drilling the 0.25-inch diameter hole.

22. Operation 2320 - Ream .50-Inch Diameter Hole

Equipment - Drill press

The burr resulting from the break through of the 0.25-inch drill is removed by the reamer.

23. Operation 2330 - Machine 3.8125-Inch, 20 UNS Thread and Finish Face Surface "C"

Equipment - Lathe, threading

The relationship between threads and surface "C" are closely held to assure minimal runout during assembly.

24. Operation 2340 - Machine 1.0625-Inch 16UN Thread and Finish Face Surface "D"

Equipment - Lathe, threading

Tolerances on threads and surface "D" are closely held to assure conformity to assembly requirements.

25. Operation 2350 - Phosphate Treat

Equipment - Chemical line

The finish machined spike is processed through a multistage cleaning and phosphate coating line.

C. CONE (8597608)

Material - Copper, strip or sheet alloy No. 110, 0.297-inch thick x 4.125-inch width, strip weight 47 lb

1. Operation 3110 - Blank Disc

Equipment - Press, mechanical, 50-ton, 6-inch stroke

This is a standard blanking operation and is needed only if the producer elects to purchase strip stock instead of discs.

2. Operation 3120 - Shear Form

Equipment - Special shear forming machine

This is a metal forming operation. Because of specific grain structure requirements for the cone, the conventional, high output, deep draw process is not approved but further study has been recommended.

3. Operation 3130 - Deburr Nose

Equipment - Sanding machine (belt)

The burrs on the nose end are removed by the sanding belt. Removal of burrs may be eliminated if the cones are processed on well-maintained tooling using adequate process control.

4. Operation 3140 - Extrude Spitback and Trim Flange

Equipment - Press, mechanical, 50-ton, 6-inch stroke

The wall thickness is reduced in the area of the spitback and the small radius is formed. Good shear forming techniques at Operation 3120 will eliminate the need for this operation.

5. Operation 3150 - Coin Taper and Flange

Equipment - Press, mechanical, 250-ton, 6-inch stroke

The taper and flange are formed to final configuration.

6. Operation 3160 - Blank 3.756-Inch Diameter

Equipment - Press, mechanical, 50-ton, 6-inch stroke

This is a standard blanking operation. A producer may elect to do this operation during Operations 3120 and 3140.

7. Operation 3170 - Machine Flange

Equipment - Lathe, automatic chucking, 6-inch swing, 24-inch centers, 25 hp

This operation will be needed only if the forming and extruding operations do not meet the specifications.

8. Operation 3180 - Drill 0.107-Inch Diameter Hole

Equipment - Drill press, automatic with shuttle table, 1/2 hp

Standard machining operation.

9. Operation 3190 - Deburr

Equipment - Holding fixture and hand tools

Removal of burrs may be eliminated if the cones are processed on well maintained tooling using adequate process control.

D. BOOM (8597609)

Material - Aluminum alloy bar, 7075, 1-3/4-inch diameter, bar weight 60 lbs

The boom would normally be produced from a forging purchased from an outside vendor. However, the forging may also be produced in-house as outlined in Operations 4110 through 4190.

1. Operation 4110 - Bar Handling

Equipment - Transfer equipment
- Sorting table
- Forklift and standard cranes

The aluminum bars are transported in bundles to the sorting tables where they are unbanded and sorted for the succeeding operation.

2. Operation 4120 - Separate Slug

Equipment alternatives
- Band saw, 16-inch, 25 hp
- Circular saw, 24-inch, 50 hp

After separation, mults must be weighed. High speed circular saw cutting will result in better cutting accuracy and a higher production rate.

3. Operation 4130 - Deburr Slug

Equipment - Vibratory system
- Automatic chamfering machine, 10 hp

Deburring the ends of the slug is necessary to remove all burrs to minimize potential damage to the forging dies. A vibratory system can accommodate slug deburring; however, use of an automatic chamfering machine will produce a preferred deburred edge at slightly higher cost. Automatic chamfering machines should incorporate double-ended flycutters with automatic load and unload.

4. Operation 4140 - Lubricate Slug

Equipment - Induction heater, 300 F, 200 kw, 200 Hz
- Spray/dip-line tanks

Slugs subject to subsequent forming require surface lubricants to reduce the frictional forces and increase tool life. The lubrication process consists of heating the lugs to 300 F, followed by a spray or dip-line using water-based colloidal graphite suspension.

5. Operation 4150 - Heat Slug

Equipment - Continuous tunnel furnace, 850 F, 1350 lb/hr
Equipment alternatives
- Induction heater, 500 kw, 200 Hz
- Oil burners
- Gas burners

The slug is heated to 850 F in a continuous furnace preceding the foring operations. This step is necessary to reduce press capacity requirements due to the alloy selected and the shape of the forging required.

6. Operation 4160 - Preform

Equipment alternatives
- Press, mechanical, 400-ton, 20-inch stroke
- Press, mechanical, 1000-ton, 24-inch stroke

The lubricated and heated slug is placed in the die and forged to the preform shape. This is the first of three steps in the not forging operation.

If the 1000-ton press is used, the preform and form steps can be done at two stations on the same press eliminating Operation 4170. The lubricated and heated slug is placed in the first cavity of the press and preformed as the first hot forging step. It is immediately transferred to the second station in the same press for the forming step to achieve the final forged shape. Both steps must be done in minimum time to prevent excessive heat loss. Forging can be accomplished in both stations simultaneously to achieve maximum productivity on the press.

7. Operation 4170 - Form

Equipment - Press, mechanical, 400-ton, 24-inch stroke

If the preform is cooled before the forming step is accomplished, cleaning, lubrication, and heating will be required prior to forming. The preform is placed in the die and formed in one stroke.

8. Operation 4180 - Clean

Equipment - Chemical line

Removes lubrication and foreign materials from the forging.

9. Operation 4190 - Heat Treat

Equipment - Furnace, 900 F, 1200 lb/hr
- Aging oven, 250 F

Equipment alternatives
- Induction heater, 500 kw, 2000 Hz
- Gas burners
- Oil burners

The purpose of this process is to attain required mechanical properties in the final part. The forged boom is exposed to a 2-hour cycle at 900 F, quenched in water at 150 F, and aged for 28 hours at 250 F.

10. Operation 4200 - Coin Center

Equipment - Press, hydraulic, 5-ton, 2-inch stroke

The forging is located in a fixture with the small end up for indenting of the center.

11. Operation 4210 - Turn Taper and Face Front End

Equipment - Lathe, automatic chucking, 12-1/4-inch swing, 24-inch center, 15 hp

This is a standard machining operation.

12. Operation 4220 - Finish Turn Small End

Equipment alternatives

- Lathe, automatic, multispindle, chucking, 5-1/4-inch swing, 25 hp
- Lathe, automatic chucking, 8-spindle, 6-inch swing, 40 hp

Standard machine operation.

If the 8-spindle lathe is used, the large and small ends can be finish machined in one operation. The forging is turned complete in two steps by double indexing technique. The small end of the boom is machined in stations 2, 4, 6, and 8. The large end uses 1, 3, 5, and 7. This option finish turns the boom in one setup and eliminates the requirement for Operations 4210 and 4230.

13. Operation 4230 - Finish Turn Large End

Equipment - Lathe, automatic chucking, multispindle, 5-1/4-inch swing, 25 hp

Standard machine operation.

14. Operation 4240 - Deburr Large End

Equipment - Holding fixture and hand tools

Removal of burrs may not be necessary if during prior operations, the parts were processed through well-maintained tooling using adequate process controls.

15. Operation 4250 - Anodize

Equipment - Chemical line

The boom is processed through multistage cleaning, etching, and hard anodizing baths for protective and functional purposes.

E. FIN (8597610)

Material - Aluminum alloy, extrusion 7075-T6, 4-1/8-inch diameter, extrusion weight 20 lb
- Aluminum alloy, extrusion 2014-T6

1. Operation 5110 - Extrusion Handling

Equipment - Transfer equipment
- Sorting table
- Forklift and standard cranes

The aluminum extrusions are transported in bundles to a sorting table where they are unbanded and sorted for the succeeding operation.

2. Operation 5120 - Saw Mult

Equipment - Abrasive saw, 10-inch blade, 10 hp

The extrusion is automatically fed to an established length for cutoff of the mult.

3. Operation 5130 - Finish Turn Outside Diameter, Drill, Ream, and Thread Tracer Cavity, Finish Face, and Cutoff

Equipment - Lathe, automatic, multispindle, bar, 5-1/8-inch capacity, 30 hp

The aluminum extrusions are machined and cut off in the multiple stations to a partially completed fin.

4. Operation 5140 - Finish Turn Angle, Drill, Ream, Face, Chamfer, and Thread Front End

Equipment - Lathe, automatic chucking, 8-spindle, double-indexing, 6-inch capacity, 40 hp

The fin is finish machined.

5. Operation 5150 - Mill 30 Degree Angle

Equipment - Boring machine, automatic, precision, 3 hp

Removal of metal for the 30 degree angle is by a hollow mill cutter to prevent bending of the fin blades.

6. Operation 5160 - Finish Front End, Rough Turn Large Diameter

Equipment - Lathe, automatic chucking, multispindle, 6-inch capacity, 30 hp

The part is chucked on the hub for machining the front end and large diameter.

7. Operation 5170 - Finish Turn Outside Diameter

Equipment - Boring machine, automatic, precision, dual spindle, (2) 3 hp

The part is chucked on the internal thread for machining of the outside diameter of the fin blades.

8. Operation 5180 - Finish Turn Rear End

Equipment - Lathe, automatic, chucking, multispindle, 6-inch capacity, 30 hp

The part is chucked on the fin outside diameter for machining of the rear end.

9. Operation 5190 - Deburr

Equipment alternatives
- Deburr machine, power, 5 hp
- Vibratory system, 15 hp

If the duburr machine is used, the machined fin is indexed for various positions for removal of the burrs by wire wheels.

With the vibratory system, selection of proper speed and media is required and internal threads must be masked to avoid damage.

10. Operation 5200 - Clean and Anodize

Equipment - Chemical line

The fin is processed through multistage cleaning, etching, and hard anodizing baths.

F. LOCKING RING (10521640)

Material - Steel, tubing, carbon, seamless, 4-inch OD x 3-inch ID, tube weight 373 lb
- Steel, bar, alloy, hot rolled, 3-7/8-inch diameter, bar weight 802 lb

1. Operation 6110 - Bar Handling

Equipment - Transfer equipment
- Sorting table
- Forklift and standard cranes

The steel bar is transported in bundles to a sorting table where it is unbanded and sorted for receiving inspection and sampling. It is then positioned for transfer to the area where the mults are seperated.

2. Operation 6120 - Finish Turn and Machine 3.8125-Inch 20UNS Thread

Equipment - Lathe, automatic, multispindle, bar, 4-inch capacity, 40 hp
- Lathe, automatic chucking (bar), 4-1/2-inch capacity, 20 hp

Standard machining operation.

3. Operation 6130 - Mill Slots

Equipment - Drill press, automatic with shuttle table, 5 hp

Two slots are cut to facilitate assembly of the locking ring into the body to secure the cone.

4. Operation 6140 - Phosphate Treat

Equipment - Chemical line

The finish machined locking ring is processed through multistage cleaning and phosphate coating line.

G. PLUG (8597488)

Material - Aluminum alloy, rod, 7075-T6 or 2024-T6, 1-inch diameter, rod weight 19 lb

1. Operation 7110 - Rod Handling

Equipment - Transfer equipment
- Sorting table
- Forklifts and standard cranes

The aluminum rod is transported in bundles to a sorting table where it is unbanded and sorted for the succeeding operation.

2. Operation 7120 - Machine, Thread, and Cut Off Plug

Equipment - Lathe, multispindle, 1.0-inch diameter capacity, 15 hp
- Lathe, automatic chucking (bar), 1-1/2-inch capacity, 10 hp

Standard screw machine operation. The plug outside diameter, is machined, threaded, and cut off.

3. Operation 7130 - Drill Spanner Holes

Equipment alternatives
- Multispindle drill, 5 hp
- Multispindle drill head

The machined plug is located in a holding fixture and the two spanner bottoming holes are drilled and deburred.

4. Operation 7140 - Deburr

Equipment - Vibratory system, 10 hp

This operation may not be required if adequate tooling is used in Operations 7120 and 7130. If the holes are drilled with deburr provisions, such as a deburr collet, this operation may be deleted.

5. Operation 7150 - Anodize

Equipment - Chemical line

The plug is processed through multistage cleaning, etching, and anodizing baths.

H. DISC (8595465)

Material - Brass, strip, alloy No. 260, 0.004-inch thick x 0.5-inch wide, roll weight 50 lb

1. Operation 8110 - Coil Handling

Equipment - Forklift
- Crane/hoist

This operation involves the transport of coil stock from receiving/stores to punch press straighteners.

2. Operation 8120 - Blank

Equipment - Press, mechanical, 10-ton, 6-inch stroke, open back, inclineable, integral coil straightener

This operation produces the blank in a single stroke.

I. PLUG AND DISC ASSEMBLY (8597489)

Operation 9110 - Bond Disc to Plug

Equipment - Automated fixturing
- Adhesive applicator

It is important that the correct amount of adhesive be applied to the plug cavity. This will minimize subsequent cleaning.

Operation 9120 - Crimp 360°

Equipment - Crimping fixture, air, 90 psi

The die under compressive forces produces a 360-degree crimp.

J. FIN AND BOOM ASSEMBLY (8597611)

1. Operation 10110 - Apply Adhesive

Equipment - Adhesive applicator

The boom thread is coated with a thread sealant prior to assembly with the fin for positive locking.

2. Operation 10120 - Assemble Fin and Boom

Equipment - Holding fixture
- Torque wrench

While the thread sealant is in the wet state, torque of 375 inch-pounds is applied.

K. CONE AND CONDUIT ASSEMBLY

1. Operation 11110 - Clean

Equipment - Cleaning line

This is a standard cleaning process to remove chips and residual soils developed during machining operations.

2. Operation 11120 - Assemble and Apply Adhesive

Equipment - Automated fixturing
- Adhesive applicator

The proper application of the adhesive will minimize the necessity of cleaning to remove excess adhesive.

L. PROJECTILE METAL PARTS ASSEMBLY (8597604)

1. Operation 12110 - Seat Cone and Conduit Assembly in Body

   Equipment - Press, hydraulic, 50-ton, 6-inch stroke

   The flange of the cone is coined during assembly for positive location with the body undercut surface.

2. Operation 12120 - Apply Thread Compound

   Equipment - Fixture with sealant compound applicator

   The sealant is applied to threads adjacent to the cone flange.

3. Operation 12130 - Install Locking Ring

   Equipment - Holding and torque fixture

   The locking ring is seated against the cone flange with 700 + 50 inch-pounds of torque.

4. Operation 12140 - Air Test

   Equipment - Special air leak test fixture

   Assemblies are placed in the fixture, which automatically performs the test for air leakage.

5. Operation 12150 - Apply Thread Compound

   Equipment - Fixture with sealant compound applicator

   The sealant is applied to body threads.

6. Operation 12160 - Assemble Wire to Spike

   Equipment - Bench

   Wire assembly is placed in spike.

7. Operation 12170 - Feed Wire Through Conduit and Preassemble Spike

   Equipment - Bench

The wire is fed through the conduit. The threads of the spike and body are hand started.

8. Operation 12180 - Apply Compound to Body Threads

Equipment - Bench

Sealant is applied to body threads and then tightened by hand.

9. Operation 12190 - Torque Spike to Body

Equipment - Holding and torque fixture

The body is clamped in the fixture and a torque of 650 + 50 inch-pounds applied to the spike.

10. Operation 12200 - Align Wire and Seat in Slot

Equipment - Bench

The wire is aligned in the 0.25-inch diameter slot and seated.

11. Operation 12210 - Assemble Terminal to Wire

Equipment - Bench, hypodermic needle, and hand crimping tool

Adhesive is injected between wire and conduit. The exposed insulation and wire are wiped clean and the terminal crimped into place.

12. Operation 12220 - Stamp Identification

Equipment - Rotary stamping machine

A rotating stamping fixture is used to indent nomenclature, year of manufacture, lot number, and contractor's identification.

M. PLUG, FUZE LOCK (8597614)

Material - Bar, carbon steel, cold finished, nonresulfurized, 1-3/4-inch diameter, bar weight 164 lb

1. Operation 13110 - Bar Handling

Equipment - Transfer equipment
- Sorting table
- Forklift and standard cranes

The steel bar is transported in bundles to sorting tables where it is unbanded and sorted for the succeeding operation.

2. Operation 13120 - Bore Cavity, Turn Thread, and Cutoff

Equipment - Lathe, automatic, multispindle, bar, 1-3/4-inch capacity, 30 hp
- Lathe, automatic chucking (bar), 2-inch capacity, 15 hp

Standard screw machine operation where the outside diameter is turned and threaded.

3. Operation 13130 - Drill Spanner Holes

Equipment alternatives
- Multispindle drill, 5 hp
- Multispindle drill head

The machined plug is located in a holding fixture and the two spanner holes drilled and deburred.

4. Operation 13140 - Deburr

Equipment - Vibratory system, 10 hp

This operation may not be required if adequate tooling is used in Operation 13130, i.e., if holes are drilled with deburr provisions such as a deburr collet.

5. Operation 13150 - Cadmium/Zinc Plate

Equipment - Chemical line

The finished plug is processed through multistage cleaning, etching, and electroplating with a protective metal plate and supplementary chromate coating.

The following parts and assemblies are to be shipped separately in suitable containers as sets,

- Fin and boom assembly - 8597611
- Fuze lock plug - 8597614
- Plug and die assembly - 8597489
- Obturator - 8597612
- Seal O-ring - MS9021-226

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PLANT EQUIPMENT PACKAGE
MODERNIZATION PROGRAM

Volume 4-1
Report No. 75-86-R-4-4
MODEL LINE DEVELOPMENT
FUZE,PD, M739

prepared for
Project Manager
Munitions Production Base Modernization
and Expansion

administered by
Picatinny Arsenal
under Contract No. DAAA21-75-C-0303

April 1976

FUZE, PD, M739

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TABLE OF CONTENTS

I. INTRODUCTION

The model line is a theoretical munitions production line related directly to the technical data package configuration and specifications. It is not intended to be a complete or sized production line that could be established in the future to produce a specified quantity of end item(s).

The model line is a benchmark made up of brief, but precise, technical information defining the production requirements of the particular end item, with process methods compatible with the proven state of the art in munitions production technology.

The model line will be the standard used by the PEP modernization team to review, analyze, and assess the active and inactive producers' capabilities to meet mobilization requirements. The model line documentation will include alternative process methods and technologies for the purpose of analysis, evaluation, and the recommendation of the most appropriate manufacturing system.

In preparing the model line for the manufacture of piece parts for the M739 fuze, a number of facts became obvious and affect the detailed design of a modernized production equipment package for this point-detonating fuze.

The technical data package prescribes not only the configuration of the piece parts but, in many cases, the manufacturing methods that must be employed, e.g., diecasting, powder metal sintering, injection molding, etc., and the types of equipment to be used for machining or forming of particular parts.

The choice of secondary operations required to provide piece parts with appropriate finishes for function and fit is left to the discretion of the manufacturer. The choice of tooling also influences the finishes achieved.

The complement of machine tools shown in the model line description is representative of the current state of the art. Substitution of one manufacturer's equipment for the equivalent model of another manufacturer is feasible in most cases. Specific model designations should therefore be regarded as illustrative examples.

To implement the model line concept in a modernized production line dedicated to a specific fuze at a given production level, total manufacturing requirements, and not just the production equipment requirements, must be satisfied. This includes careful consideration of quality assurance, material handling, tooling and fixturing, assembly, packaging, and shipping requirements.

Modernization of a particular fuze production line must also take into account the experience and skills level of the specific producer. Even fully integrated producers will require the services of some highly specialized subcontractor and the furnishing of explosive-loaded components by the Government.

The following sources of information were used in planning this model line:

1. Engineering Design Handbook, Ammunition Series: Fuzes, General and Mechanical; AMCP 706-210, DDC No. AD830289, August 1963.

2. Military Specification MIL-F-48277 (PA), Fuze, Point Detonating, M739, Less Booster Pellet, 3 January 1975.

3. Drawing No. D9258605, Fuze, PD, M739, Rev., 19 December 1974.

4. Drawing No. D8797864, Delay Plunger, M1, Assembly, Loading, Rev. E, 6 November 1969.

5. Honeywell Inc., Government & Aeronautical Products Division, Hopkins, Minn., M739 Facilitization Study, Contract DAAA 21-71-C-0225, 30 April 1975.

II. GENERAL APPROACH AND CONSIDERATIONS

Fuzes are characterized by a large number of piece parts that comprise subassemblies making up a final assembly that contains one or more explosive or pyrotechnic elements. Exploded views of the M739 fuze and M1 delay plunger are shown in Figures II-1 and II-2. Exacting inspection and test requirements must be satisfied during manufacture and assembly before completed fuzes can be accepted and shipped to the load/assemble/pack (LAP) plants. Thus, fuze production under mobilization conditions poses a number of unique problems that must be resolved in the design of a model line.

The technical data package (TDP) defines the configuration and the functional and performance requirements for the fuze and each of its piece parts. The producer must meet the quality assurance (QA) requirements embodied in the TDP. Production and inspection functions are combined in high volume fuze plant operation since numerous 100% inspections must be performed during production at a rate governed by the production flow.

Mobilization conditions demand quick response, with startup, first-article approval, and pilot lot acceptance achieved within a short, "M + 5 month," period. Experienced and highly skilled fuze engineering, production, inspection, and management personnel required to design, build, debug tooling, install equipment, obtain the necessary materials and standard items, train operators, and commence production will probably not be available. Provision should be made for phasing in automated assembly after startup while producing the initial quantities with simpler, labor intensive methods. Startup from basic materials keeps the downstream line elements idle until line inventory is built up. This can take weeks for fuzes involving numerous piece parts and process steps.

Safety, OSHA, pollution abatement, and energy conservation considerations constrain the freedom of choice for the model line designer. However, the safeguarding of life and health, protection of property and facilities, and avoidance of pollution and waste of energy are essential for smooth production in an environment of resource scarcity. Preplanning for these conditions is an important factor in model line design.

Make-or-buy decisions enter into the design of the model line. Production starts with the specified materials in the required form, shape, or

condition specified in the TDP. Explosive-loaded components, such as detonators or leads, are usually Government furnished material (GFM). Processing of some piece parts is such a specialized operation that only a few manufacturers are equipped and capable of producing these parts efficiently. This category includes not only standard fasteners but also such unique piece parts as hairsprings and drive springs. Each fuze producer usually bases his make-or-buy decisions on his in-house capabilities. The model line documentation should provide processing instructions for all piece parts. Make-or-buy decisions should be based on objective criteria including:

- Specialized technology requirements
- Skill and equipment availability
- Delivery quantity and time requirements
- Quality assurance requirements
- Economics

Specialized technology constraints for making hairsprings or black powder for fuze delay trains require facilities and skills that are unique, which very few producers possess. The long learning period required to establish such facilities and skills precludes in-house manufacture by most fuze producers, hence, purchase of these items is shown in the buy list.

Skills and equipment available in the facility of a fuze producer may cover the common fabrication and assembly operations, but may not extend to such specialized processes as diecasting, plastic molding, design, building, or debugging of specialized assembly fixtures. Under those conditions, subcontracting may become necessary.

Delivery quantities required may exceed the physical capacity of a facility, even at mobilization production rates. Subcontracting is the only quick turnaround option available to such a manufacturer. However, if all fuze producers seek the same specialist subcontractor to furnish needed key components, the capacity of the subcontractor may not meet the required volume. Without vertical planning, orderly multitier production operations will be in jeopardy under mobilization conditions.

Quality assurance requirements may be so stringent that successful completion of fuze acceptance testing can only be assured if the producer fabricates key parts in his facility, where he can exert total control. Government and producer QA personnel are cognizant of instances where parts made under subcontract failed successful assembly due to problems

of cumulative tolerances. Make rather than buy is the preferred option in those instances.

All of these criteria enter into the model line design process, together with requirements of the TDP, mobilization conditions, and constraints imposed by safety, OSHA, pollution abatement, and energy conservation considerations.

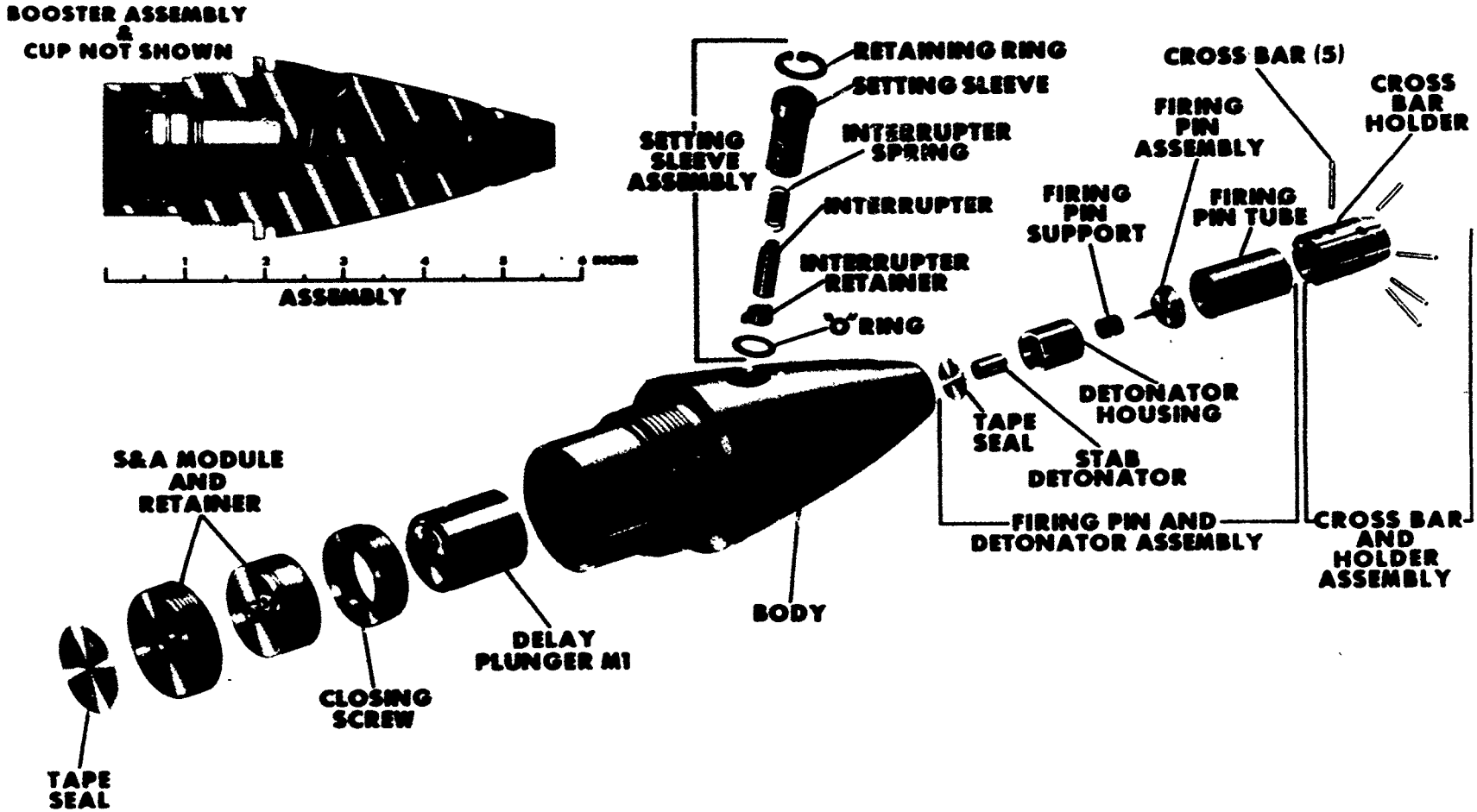

FIGURE II-1. FUZE, PD, M739, EXPLODED VIEW

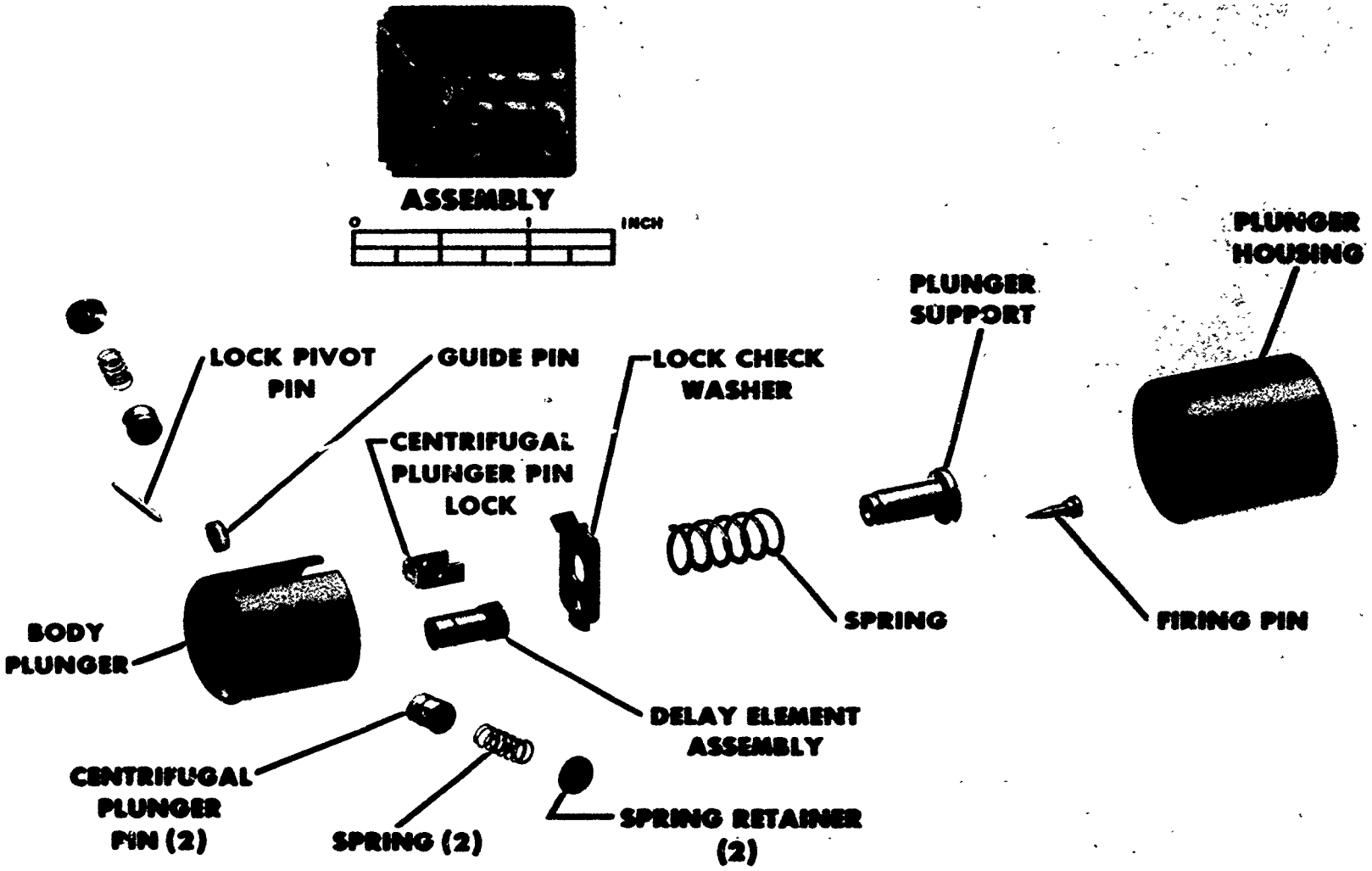

FIGURE II-2. DELAY PLUNGER, M1

III. PURCHASED COMPONENTS AND GOVERNMENT FURNISHED MATERIALS

Based on the rationale for the make-or-buy decision, as outlined in Section II, the parts list for the M739 fuze and the M1 delay plunger assembly was reviewed. It is recommended that the items listed in Table III-1 be purchased. A brief discussion of the reason for inclusion of items on this list is also included.

Since military explosives are not readily available from commercial sources, loaded explosive items must be supplied as Government furnished materials (GFM). The metal parts required for producing these items are customarily supplied by the loading facility. The required GFM explosive items for the M739 fuze and the M1 delay plunger are shown in Table III-2.

These items are supplied with certifications to indicate that they conform with the applicable specification requirements.

Transportation, handling, and storage of the explosive-loaded components are subject to all applicable safety regulations.

TABLE III-1
COMPONENTS RECOMMENDED TO BE PURCHASED

Part Number	Description	Reason
M739 Fuze		
9258610	Seal, Tape	An aluminum-backed, pressure-sensitive adhesive tape per Specification L-T-80 manufactured by a number of producers as a standard item. It is supplied in roll form for convenient blanking during final assembly of the fuze.
9258633	Pin, Module	A conventional spring pin per MIL-P-10971 available from a number of commercial producers of this type of fastener.
9258637	Disk, Pin, Setback	A simple, thin aluminum alloy disk blanked from rolls during safing and arming module assembly. Slit rolls can be procured from a variety of sources.
9258648	Disk, Pin, Lock	Blanked from thin aluminum alloy sheet during the subassembly operation for safing and arming module. Numerous suppliers furnished this material in roll form.
9258682	Seal, Disc	Blanked during assembly from a soft aluminum foil provided with a synthetic rubber adhesive backing. This commercial item is covered by a source control drawing prescribing vendor qualification requirements.
Delay Plunger, M1		
9204747	Pin, Guide	A standard spring pin per MIL-P-10971 supplied by a number of commercial specialty houses.

TABLE III-2
GOVERNMENT-FURNISHED MATERIALS

Part Number	Description	Reason
M739 Fuze		
8798331	Detonator, Stab, M55	Explosive-loaded material
9255165	Lead Cup Assembly	Explosive-loaded material
9255168	Pellet, Booster (inserted into the fuze at the LAP plant)	Explosive-loaded material
9272235	Detonator, Stab, M99	Explosive-loaded material
Delay Plunger, M1		
8844434	Delay Element, M2, Assembly	Explosive-loaded material

IV. MANUFACTURING AND ASSEMBLY PROCESSES

The requirements contained in the technical data package for the M739 fuze prescribe the material configuration, tolerances, and protective finish for each of the piece parts making up the fuze assembly. Allowances in assembly may dictate that part tolerances be held within more stringent control limits than specified in the drawings in order to meet functional and performance requirements for the assembled fuze. These circumstances severely limit the choice of processes and equipment that may be used in fuze part manufacture and assembly.

A. MANUFACTURING SEQUENCE OF OPERATIONS

There are 33 different fuze and 10 delay plunger parts that must be fabricated. Some of these items are used more than once, requiring a total of 53 manufactured piece parts in addition to the purchased items and Government furnished materials for the final M739 fuze assembly.

The fabrication equipment required to make the piece parts may be grouped into the following equipment categories:

- o Automatic screw machines
- o Punch presses
- o Other presses
- o Diecasting machines
- o Powder metal compaction presses
- o Cutoff machines
- o Injection molding machines

The process steps for manufacture of the individual piece parts are shown in the Process Description Summary in this section.

Equipment used to perform each operation, including alternative machines (identified as Eq Alt) if applicable, are also listed.

The order in which the operations are performed is shown by the operation number. These are four and five-digit numbers with the first character(s) designating the end item for that line and the three final characters indicating the numerical sequence of operations.

Opposite the operation number is a description of the operation with the equipment used listed below it. Under operation sequence, a path is shown by X's indicating steps of manufacture.

Gross capacities listed are estimated production capabilities of the equipment designated for the operation and are shown in pieces per hour. These figures are not factored for downtime or delays. As an example, a press that is capable of cycling in 1 second (i.e., 60 cycles per minute) will have a gross capacity of 3600 pieces per hour.

Tooling, fixturing, feeding and gaging provisions are not shown on the process sheets, these operations being outside the scope of this study.

B. ASSEMBLY OPERATIONS

Assembly of the M739 PD fuze is completed at the LAP plant, when the booster pellet (P/N 9255168) is added and the booster cup is re-attached to the fuze body assembly (P/N 9258606).

1. Flow Charts

The components and subassemblies comprising the M739 fuze are shown in Figure IV-2. A corresponding list for the delay plunger, M1, assembly is shown in Figure IV-3.

The chart does not necessarily show the piece parts for each subassembly and the several subassemblies in the exact sequence of their being placed into the final assembly. The purpose of these charts is to list the components in their subassembly relationship as an aid in planning the exact assembly sequence.

2. Assembly Details

As production rates increase, manual assembly of piece parts using simple fixtures becomes increasingly cumbersome, costly, and difficult to reconcile with quality assurance requirements. Mechanization of assembly operations involves not only the handling, feeding, and orienting of each piece part, but also the correct placement, attachment, and checking for presence and orientation at each assembly stage.

Assembly machines capable of performing all of these steps rapidly and reliably may utilize standard bases to which specific

tooling and fixturing are added. Several types of assembly machine bases have been used in fuze work. These include in-line indexing, in-line pallet-type, rotary continuous motion, rotary indexing, and hybrid types tooled for a specific fuze. The cost of the tooling, customizing, and debugging of the assembly machines usually far exceeds the cost of the assembly machine base. Any changeover to another fuze is both time consuming and costly. Therefore, fuze assembly machines are typically classified as special tooling excluded from the plant equipment package consisting of IPE that is set aside for piece part production.

Based on a facilitization study performed by Honeywell, Inc. for Picatinny Arsenal under Contract No. DAAA21-71-C-0225, the following approach for assembly of the M739 fuze is presented. The operations make use of a series of rotary indexing assembly machines and standard spring winders. Parts and subassemblies are handled either by conveyors or by magazines between individual assembly machines. Figure IV-4 shows the assembly equipment required for the M739 fuze exclusive of the LAP operation. Some machines are required in multiples for balanced line operation.

Figure IV-5 is the flow diagram for the safing and arming module assembly. Piece parts being fed by conveyor or magazine to the several dial machines and spring winders are listed by part number and usage.

Figure IV-6 is the flow diagram for the delay plunger (M1) assembly, including spring winders, dial machines, and material handling provisions for the associated piece parts.

Assembly of the safing and arming module, the M1 delay plunger, and other components into the M739 fuze is shown schematically in Figure IV-7.

Based on 2-8-5 shift operation as projected in the M739 facilitization study (294 operating hours per month) to assemble 500,000 fuzes per month, the number of assembly machines required may be grouped as follows:

Group	Number of Machines
Safing & arming module	21
Delay plunger M1	16
Fuze assembly	19
Total	56

This list of machines includes the various dial assembly machines and spring winders required for balanced line assembly of the M739 fuze, exclusive of LAP.

The PEP Modernization Program does not cover tooling, fixturing, or assembly machines. The description of assembly operations for the M739 fuze is included for illustrative purposes only.

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

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Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** CUP, BOOSTER (9258607) **********				
1110		Blank & Cup		
	1	Punch press, 75 ton	2800	
1120		Degrease		
		Vapor degreaser	140000	
1130		Tumble		
	1	Barrel tumber	20000	
1140		Heat Treat to T-6 Condition		
	1	Furnace, quench tank, & oven	20000	
1150		Machine Face, Chamfer & Thread		
	1	Screw machine, auto, 1-1/4 inch	1000	
1160		Degrease		
	1	Immersion degreaser	40000	
1170		Finish Metal		
	1	Metal finishing line	30000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
**********		BODY, FUZE (9258609) **********		
2110		Machine After End Complete		
	1	Bar machine, 2-5/8 inch	200	
2120		Machine Forward End Complete		
	1	Chucker, 6 inch	225	
2130		Degrease		
	1	Vibratory degreaser	6200	
2140		Broach Wrench Slots		
	1	Broach	1600	
2150		Drill Complete		
	1	Drilling machine, (special)	600	
2160		Degrease		
	1	Vibratory degreaser	6200	
2170		Stamp Identification		
	1	Stamping machine	1000	
2180		Finish Metal		
		Metal finishing line	2800	

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PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** SCREW, CLOSING (9258611) **********				
3110		Machine Complete		
	1	Screw machine, auto, 1-5/8 inch	800	
3120		Degrease		
	1	Vapor degreaser	140000	
3130		Finish Metal		
	1	Metal finishing line	30000	
********** SUPPORT, FIRING PIN (9258614) **********				
4110		Blank, Draw, & Trim		
	1	Punch press, 45 ton	2300	
4120		Degrease		
	1	Immersion degreaser	140000	
4130		Tumble		
	1	Barrel tumbler	20000	
4140		Anneal		
	1	Furnace, heat treat, 800/1450 F	30000	
4150		Descale		
	1	Chemical line	25000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** TUBE, FIRING PIN (9258616) **********				
5110		Blank, Draw, Trim, & Pierce		X
	1	Press, mechanical multiplunge	3000	
5120		Degrease		X
	1	Vapor degreaser	140000	
5130		Tumble		X
	1	Barrel tumbler	20000	
5140		Finish Metal		X
	1	Metal finishing line	20000	
********** HOUSING, DETONATOR (9258617) **********				
6110		Machine Complete		X
	1	Screw machine, auto, 1 inch	1000	
6120		Separate Chips		X
	1	Chip separator	50000	
6130		Degrease		X
	1	Immersion degreaser	140000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
6140		Final Machine		X
	1	Drill press, HS single spindle	250	
6150		Degrease		X
	1	Immersion degreaser	140000	
6160		Tumble		X
	1	Barrel tumbler	20000	
********** ASSEMBLY, FIRING PIN (9258618) **********				
7110		Mold Complete		X
	1	Injection press	900	
7120		Deflash		X
	1	Tumble blast	5000	
********** PIN, FIRING (9258619) **********				
8110		Machine Complete		X
	1	Screw machine	1700	
8120		Degrease		X
	1	Immersion degreaser	140000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** RETAINER, S&A (SAFETY & ARMING) (9258620) **********				
9110		Blank, Draw, Coin, & Pierce		X
	1	Punch press - 45 ton	2500	
9120		Degrease		X
	1	Vapor degreaser	140000	
9130		Tumble		X
	1	Barrel tumbler	20000	
9140		Machine Face, Turn Chamfer, & Thread		X
	1	Screw machine, auto, 1-1/4 inch	800	
9150		Degrease		X
	1	Vapor degreaser	140000	
9160		Electroless Nickel Plate		X
	1	Metal finishing line	10000	
********** CROSSBAR (9258623) **********				
10110		Cut to Length		X
	1	Wire cut off machine	20000	
10120		Degreaser		X
	1	Vapor degreaser	140000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
10130		Tumble		
	1	Spin dryer, 30 inch	20000	
10140		Passivate Finish		
	1	Passivation tank line	75000	
********** HOLDER, CROSSBAR (9258624) **********				
11110		Fabricate Complete		
	1	Punch press, 75 ton	3400	
11120		Degrease		
	1	Vapor degreaser	140000	
11130		Tumble		
	1	Barrel tumbler	20000	
11140		Finish Metal		
	1	Metal finishing line	50000	
********** RETAINER, INTERRUPTER (9258626) **********				
12110		Die Cast		
	1	Die casting machine	1000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
12120		Tumble		
	1	Barrel tumbler	20000	
12130		Finish Metal		
	1	Metal finishing line	60000	
********** SPRING, INTERRUPTER (9258627) **********				
13110		Wind Complete (In Assembly)		
	1	Spring winder	1000	
********** SLEEVE, SETTING (9258628) **********				
14110		Die Cast		
	1	Die casting machine	1000	
14120		Tumble		
	1	Barrel tumbler	20000	
14130		Finish Metal		
	1	Metal finishing line	60000	
********** INTERRUPTER (9258629) **********				
15110		Machine Complete		
	1	Screw machine, auto, 7/16 inch	1200	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
15120		Separate Chips		
	1	Chip separator	100000	
15130		Degrease		
	1	Immersion degreaser	140000	
15140		Passivate Finish		
	1	Passivation tank line	75000	
********** PALLET (9258631) **********				
16110		Pierce, Shave, & Blank		
	1	Punch press, mechanical, 45 ton	10000	
16120		Degrease		
	1	Vapor degreaser	140000	
16130		Lubricate		
	1	Spin enameler	100000	
16140		Cure		
	1	Oven, 310 F	100000	
********** PLATE, GEAR, UPPER (9258632) **********				
17110		Pierce, Shave, Coin, & Blank		
	1	Punch press, 45 ton	3600	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
17120		Degrease		
	1	Vapor degreaser	140000	
17130		Tumble		
	1	Barrel tumbler	20000	
17140		Lubricate		
	1	Spin enameler	100000	
17150		Cure		
	1	Oven, 310 F	100000	
********** PIN, HEAVY, SETBACK (9258634) **********				
18110		Press Blank		
	1	Compacting press, 14 ton	2000	
18120		Sinter Blank		
	1	Vacuum furnace, 3000 F	15000	
18130		Degrease		
	1	Immersion degreaser	140000	
18140		Tumble & Deflash		
	1	Barrel tumbler	10000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** SPRING, SPIN LOCK (9258635) **********				
19110		Wind Complete (In Assembly)		X
	1	Spring winder	1000	
********** SPRING, PIN SETBACK (9258636) **********				
20110		Wind Complete (In Assembly)		X
	1	Spring winder	1000	
********** SPINLOCK (9258638) **********				
21110		Compress Blank		X
	1	Compacting press, 14 ton	1000	
21120		Sinter Blank		X
	1	Vacuum oven, 3000 F	15000	
21130		Degrease		X
	1	Immersion degreaser	140000	
21140		Tumble & Deflash		X
	1	Barrel tumbler	20000	
21150		Lubricate		X
	1	Spin enamel	100000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
21160		Cure		X
	1	Oven, 310 F	100000	
********** BODY, ROTOR (9258640) **********				
22110		Die Cast		X
	1	Die casting machine	1000	
22120		Tumble & Dry		X
		Barrel tumbler	20000	
22130		Ream Hole 0.0985 Diameter		X
	1	Drill press	200	
22140		Degrease		X
	1	Immersion degreaser	40000	
22150		Finish Metal		X
	1	Metal finishing line	60000	
22160		Lubricate		X
	1	Spin enameler	100000	
22170		Cure		X
	1	Oven, 310 F	100000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** SHAFT, ROTOR (9258641) **********				
23110		Machine Complete		X
	1	Screw machine	320	
23120		Passivate Finish		X
	1	Passivation tank line	20000	
23130		Lubricate		X
	1	Spin enameler	100000	
23140		Cure		X
	1	Oven 310 F	100000	
********** GEAR, ROTOR (9258642) **********				
24110		Pierce, Shave, & Blank		X
	1	Punch press, 45 ton	3600	
24120		Degrease		X
	1	Vapor degreaser	140000	
24130		Tumble		X
	1	Barrel tumbler	20000	
24140		Lubricate		X
	1	Spin enameler	100000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

KAISER ENGINEERS

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
24150		Cure		
	1	Oven, 310 F	100000	
********** PLATE, BOTTOM (9258644) **********				
25110		Die Cast		
	1	Die casting machine	1000	
25120		Deflash		
	1	Barrel finishing machine	20000	
25130		Finish Metal		
	1	Metal finishing line	60000	
********** SHAFT, SPINLOCK (9258645) **********				
26110		Cut to Length		
	1	Wire cut off machine	40000	
26120		Degrease		
	1	Immersion degreaser	100000	
26130		Tumble		
	1	Harperizer machine	20000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
26140		Passivate Finish		
	1	Passivation tank line	75000	
********** SPACER, GEAR, PLATE (9258646) **********				
27110		Die Cast		
	1	Die casting machine	1000	
27120		Tumble & Dry		
	1	Barrel tumbler	20000	
27130		Metal Finish		
	1	Metal finishing line	30000	
********** SPRING, PIN LOCK (9258647) **********				
28110		Wind Complete (In Assembly)		
	1	Spring winder	1000	
********** PIN, ROTOR LOCK (9258649) **********				
29110		Machine Complete		
	1	Screw machine	1700	
29120		Degrease		
	1	Immersion degreaser	140000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
29130		Finish Metal		X
	1	Metal finishing line	60000	
29140		Lubricate		X
	1	Spin enameler	100000	
29150		Cure		X
		Oven, 310 F	100000	
********** PLATE, LOWER GEAR (9258651) **********				
30110		Blank, Pierce, & Shave		X
	1	Punch press, 45 ton	3600	
30120		Degrease		X
	1	Vapor degreaser	70000	
30130		Tumble		X
	1	Barrel tumbler	20000	
30140		Lubricate		X
	1	Spin enameler	100000	
30150		Cure		X
	1	Oven, 310 F	100000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
********** SHAFT, PALLET (9258652) **********				
31110		Machine Complete		
		Screw machine	650	
31120		Passivate Finish		
		Passivation tank line	75000	
31130		Lubricate		
		Spin enameler	100000	
31140		Cure		
		Oven, 310 F	100000	
********** ASSEMBLY, GEAR & PINION (9258653) **********				
32110		Die Cast Complete with Shaft		
	1	Die casting machine	1000	
32120		Tumble		
	1	Barrel tumbler	20000	
32130		Chromate Finish		
	1	Chromate tank line	10000	
32140		Lubricate		
	1	Spin enameler	100000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
32150		Cure		X
	1	Oven, 310 F	100000	
********** SHAFT, GEAR (9258654) **********				
33110		Machine Complete		X
	1	Screw machine	1450	
33120		Degrease		X
	1	Immersion degreaser	140000	
33130		Passivate Finish		X
	1	Passivation tank line	75000	
********** ASSEMBLY, ESCAPE WHEEL & PINION (9258655) **********				
34110		Die Cast Complete with Shaft		X
	1	Die casting machine	1000	
34120		Tumble		X
	1	Barrel tumbler	20000	
34130		Finish Metal		X
	1	Chromate tank line	60000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
34140		Lubricate		
	1	Spin enameler	100000	
34150		Cure		
	1	Oven, 310 F	100000	
********** WASHER, LOCK CHECK (8797869) **********				
35110		Fabricate Complete		
	1	Punch press, 45 ton	3600	
35120		Degrease		
	1	Vapor degreaser	10000	
35130		Tumble		
	1	Barrel tumbler	5000	
35140		Passivate Finish		
	1	Passivation tank line	5000	
********** SUPPORT, PLUNGER (8797870) ********** (ALTERNATE: PURCHASE COLD-HEADED)				
36110		Machine Complete		
	1	Screw machine, auto, 1 inch	550	
36120		Degrease		
	1	Immersion degreaser	10000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
36130		Separate Chips		X
	1	Chip separator	5000	
37140		Finish Metal		X
	1	Metal finish line	5000	
********** HOUSING, PLUNGER (8797874) **********				
37110		Blank, Draw, Trim, & Pierce		X
	1	Transfer press	2400	
37120		Tumble		X
		Barrel tumbler	5000	
37130		Separate Chips		X
		Chip Separator	5000	
37140		Finish Metal		X
	1	Metal finish line	5000	
********** PIN, FIRING (8797875) **********				
38110		Machine Complete		X
	1	Screw machine, auto, 7/16 inch	1100	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
38120		Degrease		
	1	Immersion degreaser	10000	
38130		Separate Chips		
	1	Chip separator	5000	
38140		Finish Metal		
	1	Metal finish line	5000	
********** BODY, PLUNGER (8797877) **********				
39110		Form, Counterbore, Drill, & Cut Off		
	1	Screw machine, auto, 1-1/4 inch	600	
39120		Mill Slot		
	1	Machine, multipurpose	650	
39130		Drill, Ream, & Chamfer		
	1	Special dial indexing machine	750	
39140		Spot drill, Ream, & Tap		
	1	Machine, multipurpose	500	
39150		Finish Outside Diameter		
	1	Grinder	2000	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

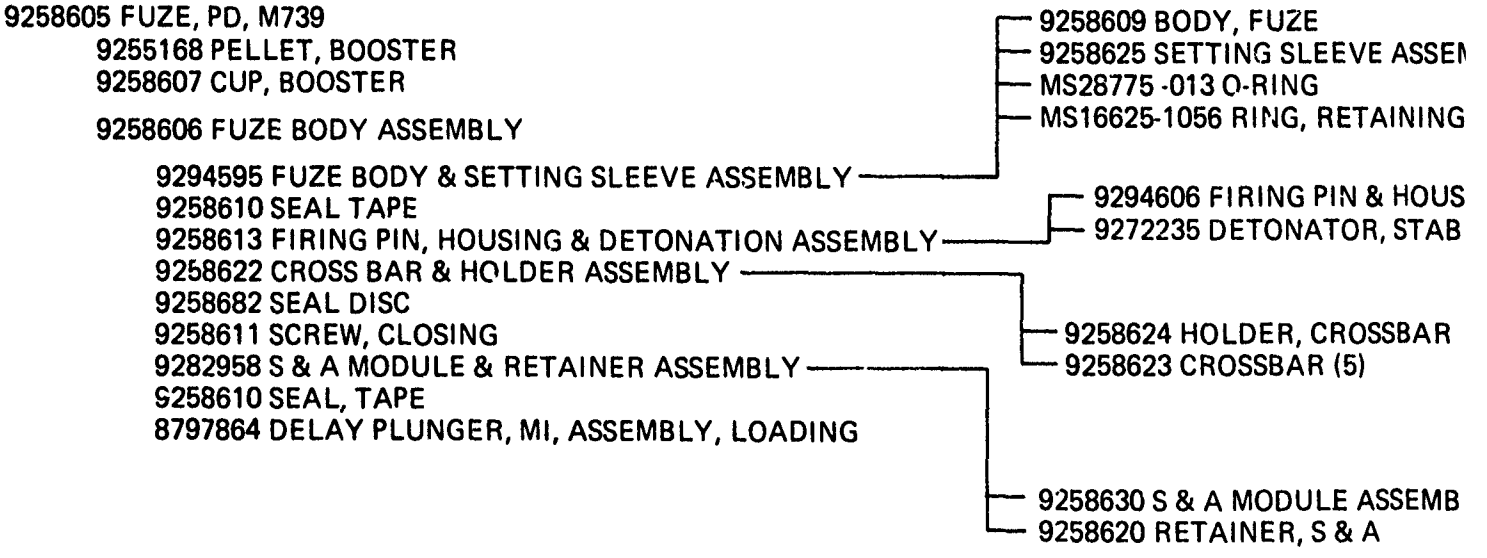
Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
39160		Deburr		
	1	Deburring machine, custom built	850	
39170		Tumble		
	1	Barrel tumbler	7000	
39180		Passivate Finish		
	1	Passivation tank line	5000	
********** LOCK, PLUNGER PIN (8797878) **********				
40110		Fabricate Complete		
	1	Punch press, 45 ton	3600	
40120		Degrease		
	1	Vibratory degreaser	10000	
40130		Tumble		
	1	Barrel tumbler	5000	
40140		Finish Metal		
	1	Metal finish line	5000	
********** PIN, LOCK, PIVOT (8797879) **********				
41110		Cut to Length		
	1	Cut off machine	2400	

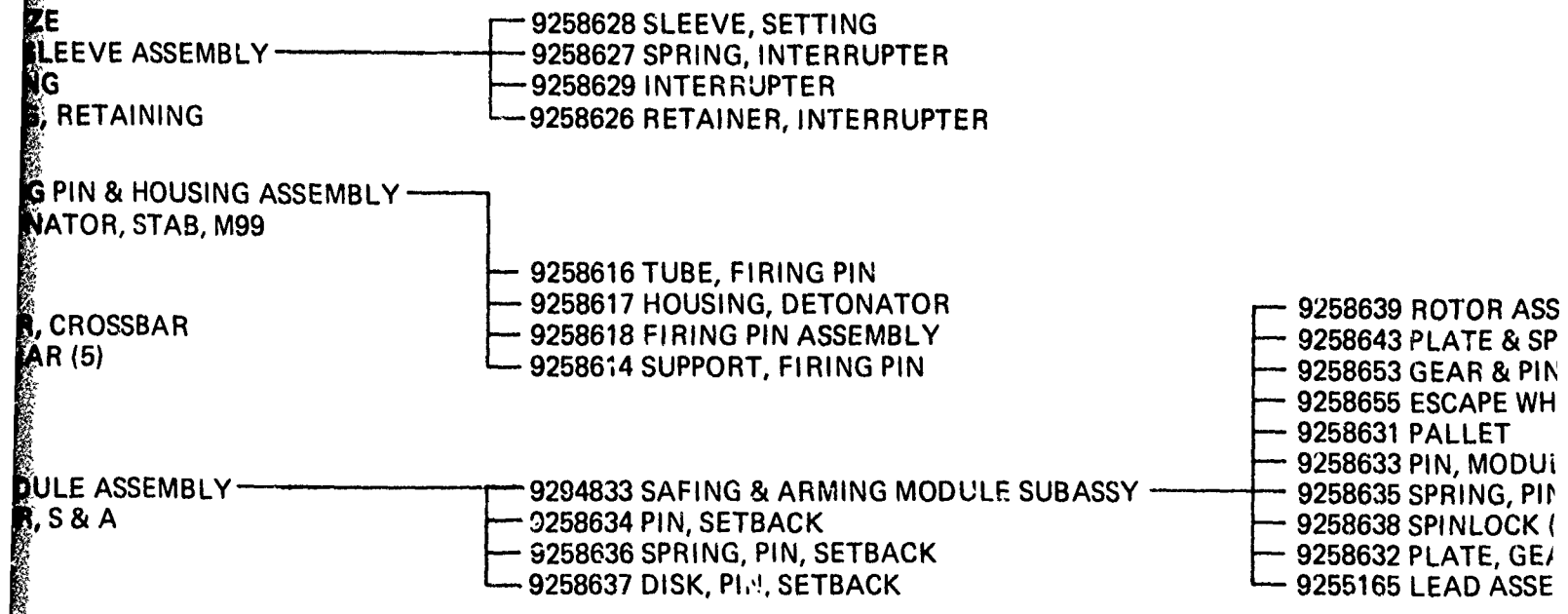
PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
41120		Degrease		
	1	Vapor degreaser	5000	
41130		Tumble		
	1	Barrel tumbler	5000	
41140		Finish Metal		
	1	Metal finish line	55000	
********** RETAINER, SPRING (8797880) **********				
42110		Fabricate Complete		
	1	Punch press, 45 ton	3600	
42120		Degrease		
	1	Vapor degreaser	10000	
42130		Tumble		
	1	Barrel tumbler	5000	
42140		Passivate Finish		
	1	Passivation tank line	5000	
********** PIN, PLUNGER (8797882) **********				
43110		Machine Complete		
	1	Screw machine, auto, 7/16 inch	850	

PROCESS DESCRIPTION SUMMARY
M739 FUZE
PEP MODERNIZATION PROGRAM

Oper No.	Eq Alt	Operation Description / Equipment Description	Grs Capy, Pcs/Hr	Operations Sequence M739
43120		Degrease		
	1	Immersion degreaser	10000	
43130		Separate Chips		
	1	Chip separator	5000	
43140		Heat Treat		
	1	Heat treat oven	5000	
43150		Centerless Grind		
	1	Grinder	2000	
43160		Tumble		
	1	Vibratory system	5000	
43170		Finish Metal		
	1	Metal finishing line	5000	


9258605 FUZE, PD, M739
9255168 PELLET, BOOSTER
9258607 CUP, BOOSTER
9258606 FUZE BODY ASSEMBLY
9294595 FUZE BODY & SETTING SLEEVE ASSEMBLY
9258609 BODY, FUZE
9258625 SETTING SLEEVE ASSEM
MS28775 -013 O-RING
MS16625-1056 RING, RETAINING
9258610 SEAL TAPE
9258613 FIRING PIN, HOUSING & DETONATION ASSEMBLY
9294606 FIRING PIN & HOUS
9272235 DETONATOR, STAB
9258622 CROSS BAR & HOLDER ASSEMBLY
9258682 SEAL DISC
9258611 SCREW, CLOSING
9258624 HOLDER, CROSSBAR
9258623 CROSSBAR (5)
9282958 S & A MODULE & RETAINER ASSEMBLY
S258610 SEAL, TAPE
8797864 DELAY PLUNGER, MI, ASSEMBLY, LOADING
9258630 S & A MODULE ASSEMB
9258620 RETAINER, S & A


ZE
LEEVE ASSEMBLY
NG
, RETAINING
9258628 SLEEVE, SETTING
9258627 SPRING, INTERRUPTER
9258629 INTERRUPTER
9258626 RETAINER, INTERRUPTER
G PIN & HOUSING ASSEMBLY
NATOR, STAB, M99
9258616 TUBE, FIRING PIN
9258617 HOUSING, DETONATOR
9258618 FIRING PIN ASSEMBLY
9258614 SUPPORT, FIRING PIN
R, CROSSBAR
AR (5)
ULE ASSEMBLY
R, S & A
9294833 SAFING & ARMING MODULE SUBASSY
9258634 PIN, SETBACK
9258636 SPRING, PIN, SETBACK
9258637 DISK, PIN, SETBACK
9258639 ROTOR ASS
9258643 PLATE & SP
9258653 GEAR & PIN
9258655 ESCAPE WH
9258631 PALLET
9258633 PIN, MODUI
9258635 SPRING, PI
9258638 SPINLOCK (
9258632 PLATE, GE/
9255165 LEAD ASSE

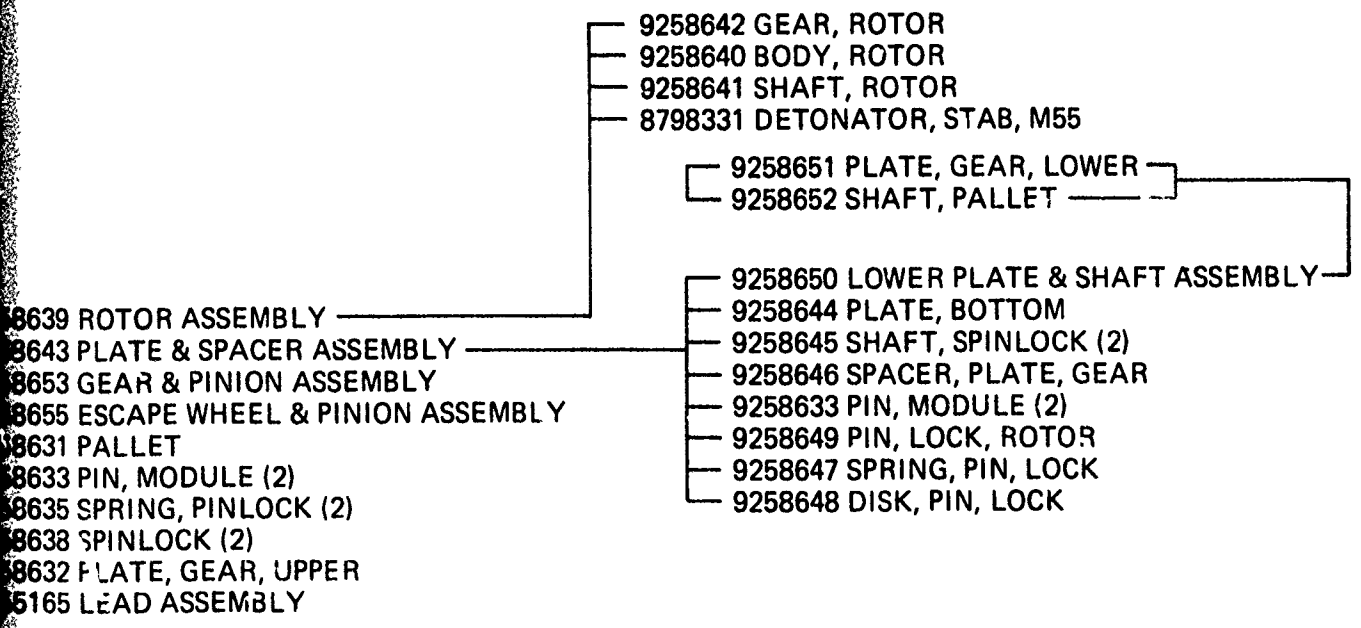


FIGURE IV - 2

FUZE ASSEMBLY SEQUENCE

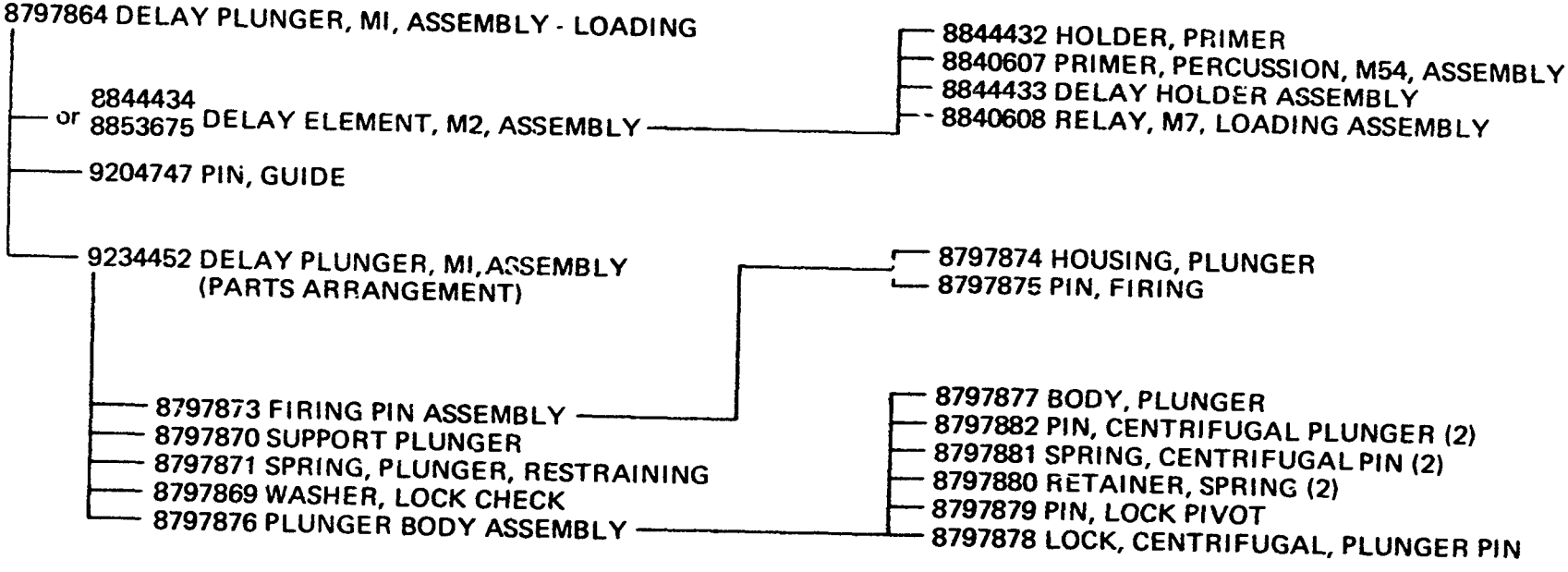
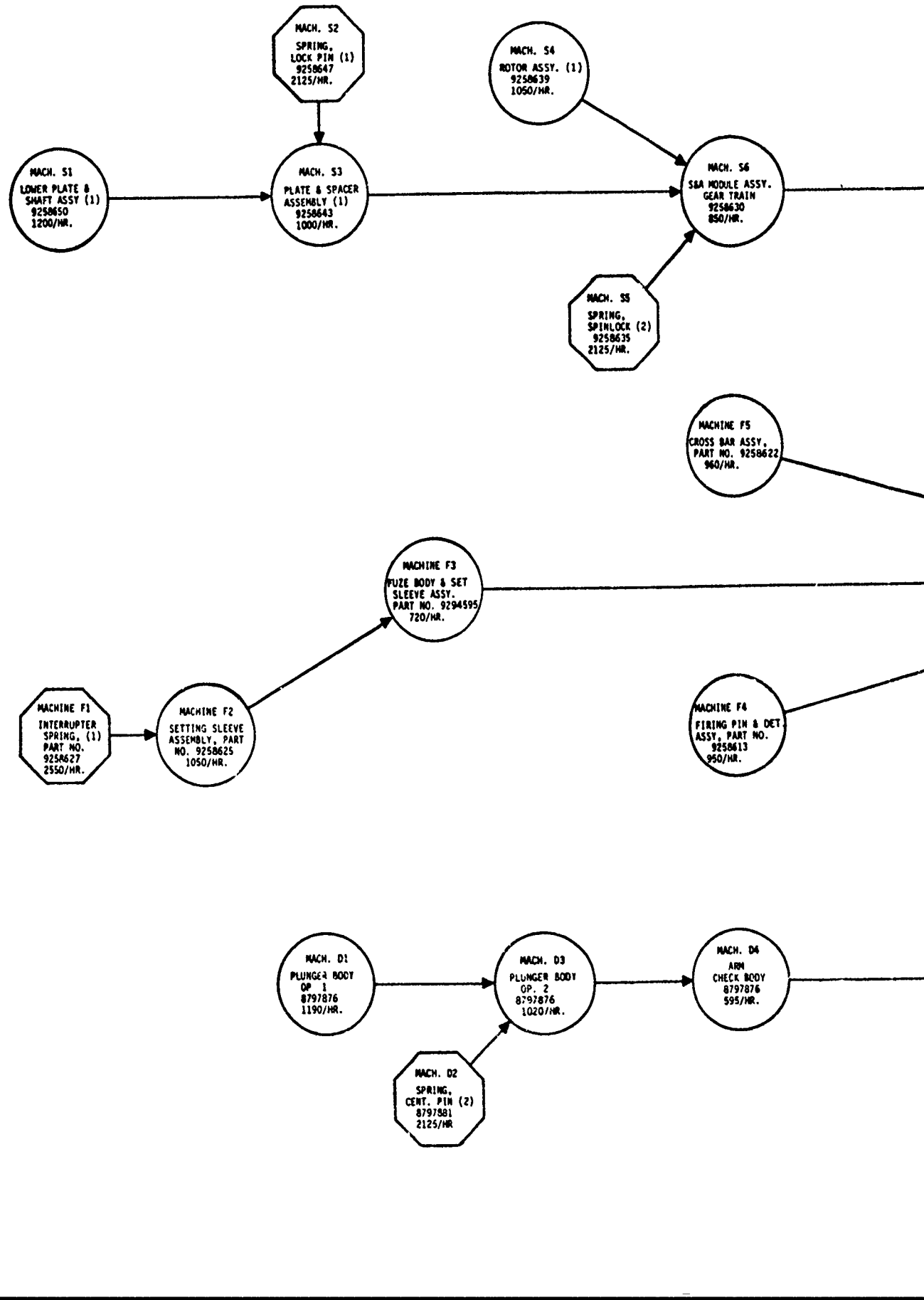


FIGURE IV - 3

MI DELAY PLUNGER ASSEMBLY SEQUENCE

FUZE M739


MACH. S1
LOWER PLATE & SHAFT ASSY (1)
9258650
1200/HR.
MACH. S2
SPRING, LOCK PIN (1)
9258647
2125/HR.
MACH. S3
PLATE & SPACER ASSEMBLY (1)
9258643
1000/HR.
MACH. S4
ROTOR ASSY. (1)
9258639
1050/HR.
MACH. S5
SPRING, SPINLOCK (2)
9258635
2125/HR.
MACH. S6
S&A MODULE ASSY. GEAR TRAIN
9258630
850/HR.
MACHINE F5
CROSS BAR ASSY, PART NO. 9258622
960/HR.
MACHINE F3
FUZE BODY & SET SLEEVE ASSY.
PART NO. 9294595
720/HR.
MACHINE F1
INTERRUPTER SPRING, (1)
PART NO.
9258627
2550/HR.
MACHINE F2
SETTING SLEEVE ASSEMBLY, PART NO. 9258625
1050/HR.
MACHINE F4
FIRING PIN & DET ASSY, PART NO.
9258613
950/HR.
MACH. D1
PLUNGER BODY
OP 1
8797876
1190/HR.
MACH. D2
SPRING, CENT. PIN (2)
8797881
2125/HR
MACH. D3
PLUNGER BODY
OP. 2
8797876
1020/HR.
MACH. D4
ARM
CHECK BODY
8797876
595/HR.

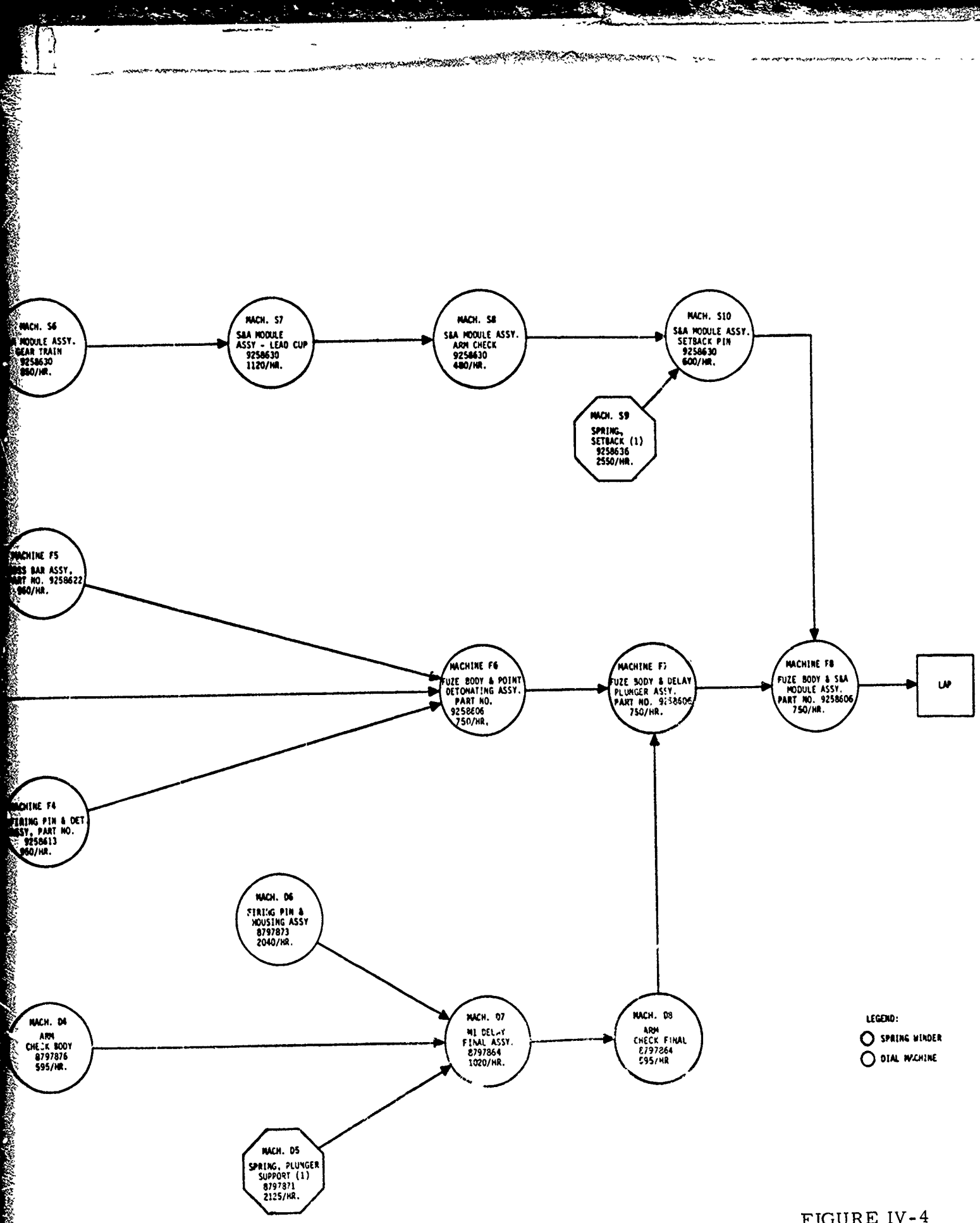


FIGURE IV-4
ASSEMBLY SCHEMATIC
FUZE M739

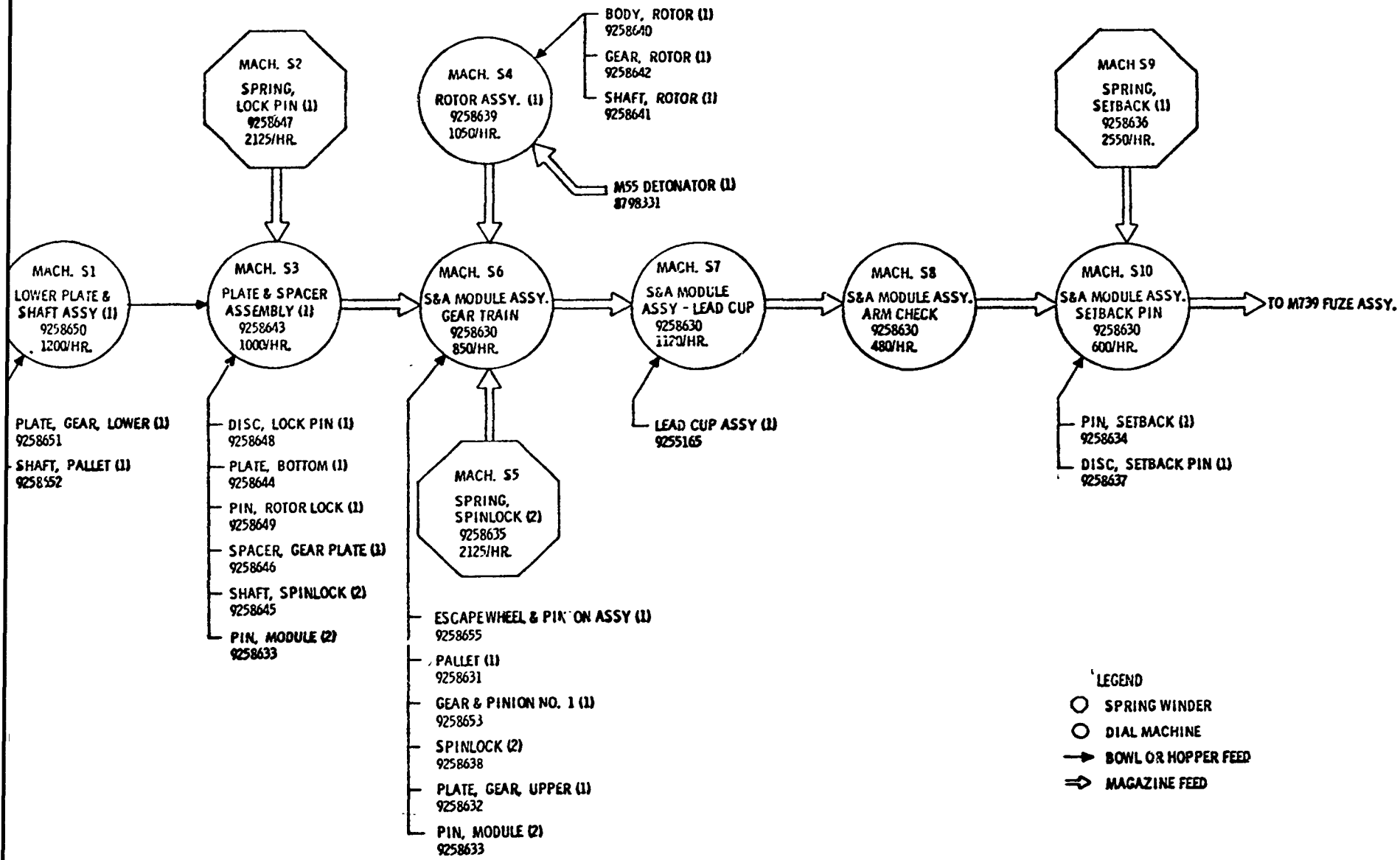


FIGURE IV-5
SAFING AND ARMING MODULE ASSEMBLY
FUZE M739

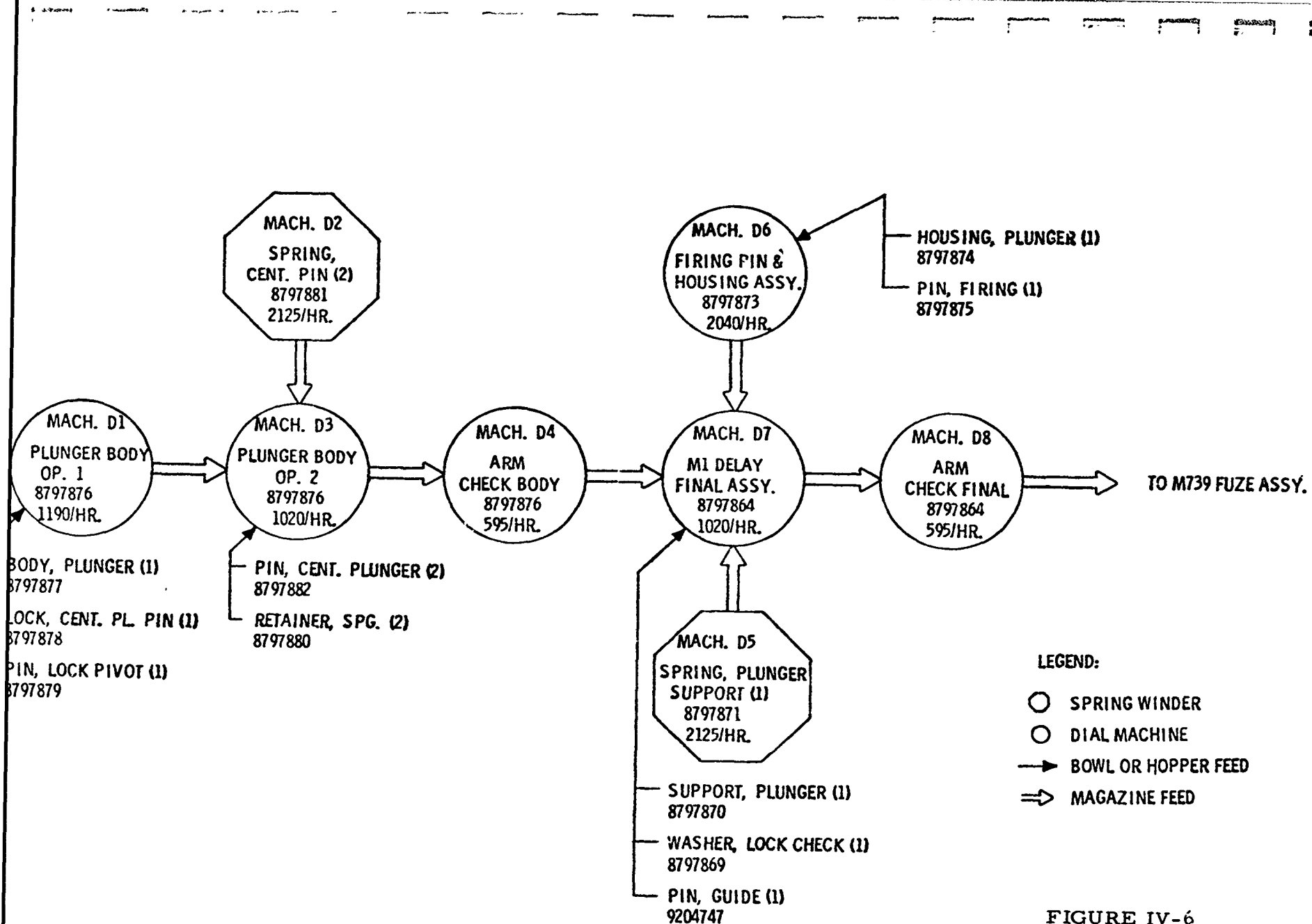


FIGURE IV-6
DELAY PLUNGER ASSEMBLY
FUZE M739

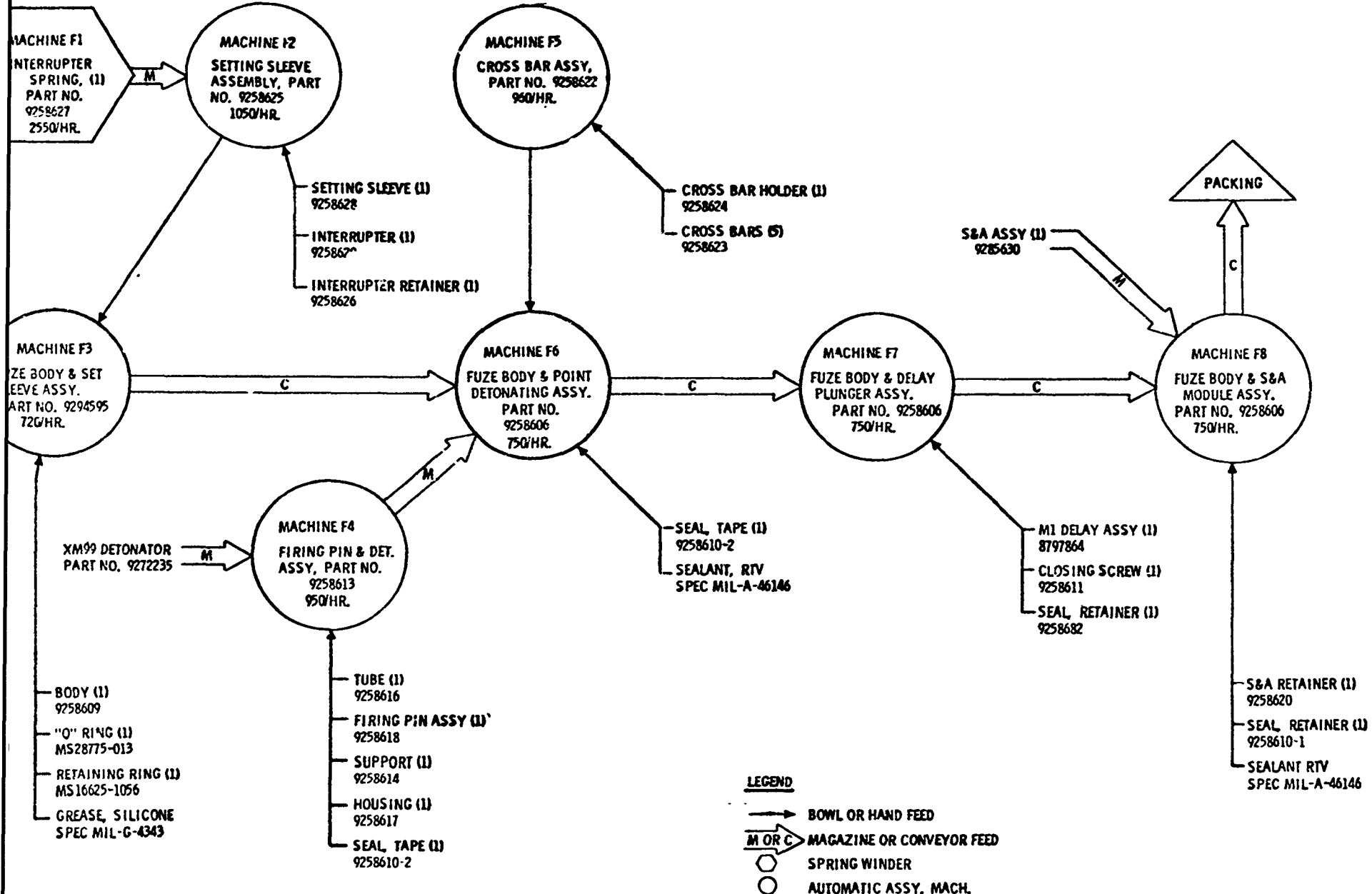


FIGURE IV-7
FINAL ASSEMBLY
FUZE M739

V. EQUIPMENT REQUIRED FOR MANUFACTURE OF FUZE PIECE PARTS

The production equipment package required for the manufacture of the piece parts comprising the M739 fuze is derived from the process sheets. This equipment may be grouped generally by type. Actual quantities for balanced fuze metal parts production will be determined by time standards appropriate to the tooling, feeding, and material handling devices employed and the efficiency of operations realized. For purposes of the model line, only a listing by type of equipment is presented.

A. STANDARD MACHINE TOOLS

Based on efficient part processing considerations, the following machine tool types are required for producing fuze piece parts:

- Presses and press accessories
- Bar, chucking, and screw machines
- Miscellaneous production equipment

In most cases, a number of machine tool suppliers can furnish equipment meeting these requirements. Specific manufacturers' model designations are used to illustrate specific equipment that has been used for making such piece parts in the past. Other equivalent equipment can be utilized depending on availability and ability to hold tolerances required by the technical data package and performance requirements.

1. Presses and Press Accessories

The complement of presses and press accessories required for the fabrication of the listed piece parts is shown in Table V-1. The coiled stock feeding accessories are essential for efficient production and for operator safety. There are several suitable punch press makes, but there may be few substitutes for the Waterbury-Farrel ICOP equipment.

2. Bar, Chucking, and Screw Machines

The automatic turning machines in this equipment category are multiple and single spindle machines selected on the basis of stock size capacity, cycle times, and tooling features to allow efficient processing to required tolerances while providing

automatic feeding of bar stock or pieces. Other selection criteria include cooling system adequacy and efficient chip removal. The availability of standard accessories for cutting, drilling, reaming, threading, and the necessary cams for machine actuation is also an important consideration in specifying individual pieces of equipment. The machines in this category together with the corresponding piece parts are shown in Table V-2. Specific equipment shown under the illustrative example column is intended to aid in the definition of required and desired machine features for the model line.

3. Miscellaneous Production Equipment

In addition to presses and automatic turning machines, fuze piece part manufacturing requires a number of different machines. For the sake of convenience in tabulation of requirements, these machines have been grouped in this category, which includes machines to perform the following processes:

- o Broaching
- o Diecasting
- o Grinding
- o Injection molding
- o Spin dipping
- o Wire cutoff

The required characteristics for this equipment are shown in Table V-3.

B. SPECIALIZED EQUIPMENT

In addition to the standard machine tools required for manufacturing fuze piece parts, special equipment is needed for chemical or heat treatment, finishing, and part/chip separation. In some multiline production facilities, this specialized equipment serves a number of production departments and product lines, rather than being dedicated to a single fuze. Such installations are usually larger and more versatile in terms of processes, material handling options, and auxiliary equipment for pollution abatement, energy conservation, and disposal of scrap and wastes.

Specialized equipment of this nature dedicated to a single fuze line is usually smaller, more specifically selected, and frequently custom built for a particular fuze part. Often this specialized equipment is classified as tooling rather than facilities because it cannot be used for another product or piece part without extensive redesign and rebuilding.

For the purpose of identification and presentation, the specialized equipment required for fuze piece part production is listed under the following process headings:

- o Metal coating, plating, and chemical treatment equipment
- o Degreasing and cleaning equipment
- o Tumbling, drying, and blast finishing equipment
- o Parts/chips separator equipment
- o Heat treatment equipment
- o Specialized drilling, tapping, boring equipment

These specialized equipment lists are intended to serve as examples since individual producers may have their own preferences for carrying out the finishing operations, especially where alternative processes are permitted by the technical data package or where the choice of implementation is left to the discretion of the producer.

1. Metal Coating, Plating, and Chemical Treatment Equipment

The metal finishing requirements for the M739 fuze parts are shown in Table V-4. Eight distinct finishes are called out in the technical data package for 30 piece parts made from carbon or corrosion-resisting steel, aluminum, zinc, and brass.

Each of the specified finishes involves subjecting the piece parts to a sequence of immersions into hot or cold rinses, treatment solutions, neutralizers, or the like before the fully treated parts are dried prior to subsequent processing or assembly operations.

A variety of equipment types is available for performing the chemical treatments. They differ mainly in the manner of loading, handling, and unloading the piece parts during the processing sequence and in the layout, control, and operation of the processing tanks.

Some bulk processing machines consist of a series of adjacent tanks, each being equipped with its own parts container. The machine operates on the batch principle. The initial quantity of piece parts is transferred into the parts container of the first tank for the first of several treatment steps. Upon completion of this treatment, the parts (not the containers) are transferred to the next tank by means of a chute, which empties

the parts into the parts container of the second tank. The material, construction, and any agitation of these containers are appropriate to the process requirement at each step.

Other chemical treatment lines incorporate conveyors above a line of tanks that serve to transport piece parts contained in a given container from tank to tank and into each tank. Programmed hoists and any needed agitation equipment can be incorporated into the conveying system, as required. The most advanced multitreatment processing equipment incorporates not only the tanks, the conveyance device, and the parts containers but also a programmer for sequencing and timing the individual process steps, controls for maintaining the necessary process conditions in the tanks, such as temperature, chemical concentration, etc., as well as treatment equipment for pollution abatement and recycling of purified fluids.

In view of this variety of approaches and implementation options, it is difficult to elect one particular chemical treatment equipment as a model.

2. Degreasing and Cleaning Equipment

A variety of vapor degreasing equipment is available using chlorinated hydrocarbons in the vapor phase, as liquid sprays, or as warm or boiling-liquid immersion baths. The choice of equipment is influenced by the type, quantity, and tenacity of the soil adhering to the parts; the size, shape, and quantity of workpieces to be cleaned; and the means of handling the piece parts before, during, and after the degreasing operation. Not all soils can be removed by vapor degreasing, hence other processes and auxiliary equipment, such as chip separators, may be required. Cutting fluids containing large amounts of water, insoluble soaps, or sulfated fatty oils may preclude the use of the vapor degreasing process. Most fuze manufacturers select their part manufacturing processes to assure compatibility of cutting fluids with the degreasing fluids used. Based on the manufacturing techniques employed, the fuze piece parts have been grouped into three categories according to increasing difficulty of soil removal and the corresponding cleaning procedures:

- o Vapor phase only
- o Liquid and vapor phase
- o Liquid and vapor phase with vibration applied

Equipment details for each of these categories are shown in Table V-5.

3. Tumbling, Drying, and Blast Finishing Equipment

This category comprises machines used for removal of flash and fine burrs from fabricated parts and machines to dry parts after such operations or subsequent to in-process cleaning. The choice of equipment in this category is influenced by the type of tooling used on the fabricating equipment and, therefore, each fuze producer prefers those finishing machines giving the best results in his shop. The equipment shown in Table V-6 reflects the choice made for the M739 fuze facilitization study.

4. Parts/Chips Separator Equipment

Chips generated in machining operations, especially with some cutting fluids, tend to cling to the parts. Positive separation of chips and any extraneous material from the parts is necessary prior to finishing and secondary machining operations. The part/chip separators shown in Table V-7 were specified in the M739 fuze facilitization study.

The chip wringer is used to remove the cutting fluid from the chips generated in all automatic screw machine fabrication operations to facilitate recycling both metal chips and cutting fluids.

5. Heat Treatment Equipment

Several of the fuze parts require annealing, solution heat treatment, and precipitation hardening (aging), sintering, and oven curing of lubricants. The equipment required for these operations is shown in Table V-8.

The metallurgical requirements of the treatment require careful control of temperature and time employed in the soak, quench, and aging cycles for the specific components involved. The sintering atmosphere for the tungsten or stainless steel powder parts and the brass anneal atmosphere must also be controlled. Combustion products in heat treatment furnaces generally have a detrimental effect on aluminum parts; therefore, control of the furnace atmosphere is desirable for most processes.

Heat treatment equipment incorporating these characteristics and controls may be used in the laboratory for all of these operations by proper adjustment and cycling. For high volume production, however, dedicated equipment selected for specific treatments is preferred.

6. Specialized Drilling, Tapping, and Boring Equipment

The configuration, machining requirements, and production rates for several fuze parts are such that standard machine tools are ill-suited for particular high volume production operations. Two specific M739 fuze parts fall into this category: P/N 9258609 (body, fuze) and P/N 8797877 (body, plunger).

Efficient production of these parts to meet configuration, functional, and quality assurance specifications requires special machines. Although these machines utilize standard machine modules or bases, the special tooling and fixtures have to be custom designed and built, followed by thorough debugging, before production can commence. The cost of the machine base is relatively low in relation to the total price of the tooled and debugged equipment. Adapting such highly specialized machines to the production of other fuze parts amounts to the implementation of a new design on the same machine base. This situation warrants the classification of the equipment as special tooling, similar to the practice followed in categorizing assembly machines. Table V-9 lists the specialized machines required for drilling, boring, and tapping the two M739 fuze piece parts. This table is intended to identify the equipment requirements and not as a specification for special machine tools.

The operations described above are summarized in Tables V-1 through V-9 following.

TABLE V-1

PRESSES AND ACCESSORIES

FUZE M739

Type	General Characteristics	Illustrative Example	Part Number Ref
Punch press, 45-ton	Mechanical, single c... single action, open ... inclinable, (OBI), clutch and air brake, 3-in stroke minimum, 75 to 250 strokes per minute, fly wheel type, complete with electrical controls and automatic lubricator	45-ton Perkins OBI Model No. 550B or equal	9258614 9258620 9258631 9258632 9258642 9258651 8797869 8797878 8797880
Punch press, 75-ton	Mechanical, single crank, single action, open back inclinable, (OBI), air clutch and air brake, 4-in stroke minimum, 75 to 150 strokes per minute, flywheel type, complete with electrical controls, timing relay, and automatic lubricator	75-ton Perkins OBI Model No. 700B, or equal	9258607 9258624

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TABLE V-1 (Cont)

Type	General Characteristics	Illustrative Example	Part Number Ref
3. Powder compacting press, 14-ton	Automatic, with motorized upper punch adjustment and vibrated fill shoe, 4-in ram stroke (max), fill range to 2-5/8 in, 40 strokes per minute, minimum, with air clutch, air brake, tonnage indicator and overload safety device	Dorst Model TPA 12 or equal	9258634 9258638
4. Plunger press, individual cam operated	12 plungers, 9-in stroke, 70 strokes per minute, with automatic feed, 20-hp (min) drive motor	Waterbury-Farrel Model 2012, or equal	9258616 8797874
5. Marking press, general purpose	Adequate size to accept the fuze body and stamp the required legend per drawing callout, 3-hp motor		9258609
6. Roll feeder/ straightener	Power driven, for 1/8-inch thick by 8-in wide coiled stock (max), for feed rates between 20 and 120 feet per minute, adjustable to fit requirements of presses (1 & 2 above) portable	Littell Model 308 7 PDL or equal	(See P/N listed under 1 & 2 above)

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TABLE V-1 (Cont)

	Type	General Characteristics	Illustrative Example	Part Number Ref
7.	Stock cradle	Power driven, 3/4-hp, with standard electrical controls, featuring hardened and polished rolls, to be used with roll feeder/ straightener (above)	Rowe Mach. & Mfg. Co. Model 2015-J or equal	(See P/N listed under 1 & 2 above)
8.	Strip scrap chopper	Capacity 1/16-in thick by 3-in wide, 3/4-hp, with standard electrical controls, to fit punch press (1 & 2) above	Durant Tool Company Model 100-15 or equal	(See P/N listed under 1 & 2 above)

TABLE V-2

AUTOMATIC TURNING MACHINES

Type	General Characteristics	Illustrative Example	Part Number Ref
1. Lathe, automatic, chucking, 8-spindle	Horizontal 8-spindle chucking automatic, 6-in chucking capacity, spindle speed range 500 to 1200-rpm, 40-hp (min) motor, standard electric controls, hydraulics, and coolant system, with selected accessories	Acme-Gridley Model 6-in RPA-8 or equal	9258609
2. Automatic bar machine 6-spindle	Horizontal 6-spindle bar automatic, 7/16-in dia bar capacity, spindle speeds to 2500-rpm, (min), 7.5-hp (min) motor, standard electric controls, hydraulics, and coolant system, with selected accessories	Acme-Gridley Model 7/16-in RA-6 or equal	9258629 8797875 8797882
3. Automatic bar machine, 6-spindle	Horizontal 6-spindle bar automatic, 1-in dia bar capacity, spindle speeds to 2500-rpm (min), 40-hp (min) motor, standard electric controls, hydraulics, and coolant system, with selected accessories	Acme-Gridley Model 1-in RAN-6 or equal	9258617 8797870
4. Automatic bar machine, 6-spindle	Horizontal 6-spindle bar automatic, 1-1/4-in dia bar capacity, spindle speeds to 2500-rpm (min) 25-hp (min) motor, standard electric controls, hydraulics, and coolant system, with selected accessories	Acme-Gridley Model 1-1/4-in RA-6 or equal	8797877

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TABLE V-2 (Cont)

	Type	General Characteristics	Illustrative Example	Part Number Ref
5.	Automatic bar machine, 8-spindle	Horizontal 8-spindle bar automatic, 1-1/4-in dia bar capacity, spindle speeds to 2500-rpm (min), 40-hp (min) motor, standard electric controls, hydraulics, and coolant system, with selected accessories	Acme-Gridley Model 1-1/4-in RB-8 or equal	9258607 9258620
6.	Automatic bar machine, 8-spindle	Horizontal 8-spindle bar automatic, 1-5/8-in dia bar capacity, spindle speeds to 2500-rpm (min), 40-hp (min) motor, standard electric controls, hydraulics and coolant system, with selected accessories	Acme-Gridley Model 1-5/8 in RBN-8 or equal	9258611
7.	Automatic precision lathe	Single-spindle precision automatic lathe, 5/32-in dia bar capacity, spindle speeds to 10,000-rpm, 2-hp motor, with selected accessories	Bechler Model AS-4 or equal	9258652

TABLE V-2 (Cont)

	Type	General Characteristics	Illustrative Example	Part Number Ref
8.	Automatic screw machine	Automatic screw machine, 5/32-in dia bar capacity, with coil feed and stock straightener, rotating tool-head speeds to 6000-rpm, 3/4-hp main motor, 1/2-hp straightner motor, complete with coolant system and accessories	Esco Model Escomatic D2 or equal	9258619

TABLE V-3

MISCELLANEOUS PRODUCTION EQUIPMENT

Type	General Characteristics	Illustrative Example	Part and Number Ref
Surface broach	Horizontal continuous surface broaching machine, mechanical 60-in (max) broach length, cutting speed range 10 to 50-fpm, 30-hp drive motor, chain drive, with coolant pumps and motors, complete with complement of accessories	Foote-Burt Co. Model Foote-Burt 15-60 or equal	9258609
Diecasting machine	Automatic zinc diecasting machine, high speed, 1.25-oz (max) shot weight, 60 to 80 shots per minute, 1-7/8 by 1-7/8-in die capacity, with control panel	Gries Reproducer Co. Model Dynacast A-2 or equal	9258626 9258628 9258640 9258644 9258646
Diecasting machine	Automatic injected metal assembly machine, with vibratory part-feeder, control console, assembly process unit, and operating head, air operated (80-psi min), single-phase, 220/440-vac, 60-Hz requires 1/2-gpm water	Fisher Gauge, Ltd. Model 30 series or equal	9258653
Centerless grinder	External centerless grinding machine, infeed 0 to 4.75-in (max) stock diameter, 20-hp main drive, 1-hp (min) regulating wheel drive, 1-hp hydraulic pump motor, 3/4-hp coolant pump motor	Cincinnati Milacron No. 2 or equal	8797877

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TABLE V-3 (Cont)

	Type	General Characteristics	Illustrative Example	Part and Number Ref
5.	Injection molding press	Reciprocating screw-type injection molding press 120 tons, for thermoset plastics, 500 grams capacity, hydraulic mold clamping with 8-in clamp stroke, 3-position index table, 40-hp drive motor, control panel, automatic ejector and loader	Penwalt Stokes Model 755-2 or equal	9258618
6.	Dip spin machine	Dip spin machine with 1.75 hp spin motor and 1.5-hp hydraulic lift, for 16-in dia x 6-in deep steel baskets, with automatic closing door	Ronci Machine Co. Model R 200 or equal	9258632 9258638 9258640 9258641 9258649 9258651 9258652
7.	Cutoff machine	Automatic wire cutoff machine, 0.050-in (max) dia, 1 inch max length wire, pneumatic operated, 2-hp motor and 1/2-hp motor drives	Patterson (Geo.C.) or equal	9258623 9258645 8797879

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TABLE V-4

METAL COATING, PLATING AND CHEMICAL TREATMENT EQUIPMENT

M739 FUZE PARTS

MIL-STD-171 Finish No.	Type of Finish	Base Material	Part Number Ref
1.1.2.3	Cadmium coating Plating Specification QQ-P-116 Type II, Class 3, 0.0002-in thick	Steel	9258624 8797870 8797874 8797875 8797878 8797879 8797882
1.4.3.1	Nickel coating, electroless Specification MIL-C-26074 Class 1 (as coated condition)	Aluminum	9258620
1.9.2.3	Zinc coating Electrodeposited zinc, Specification QQ-Z-325, Type II with supplementary treatment, normal color, not bleached or clear, class 3, 0.0002-in thick	Steel	8797870
5.4.1	Finish for corrosion-resisting steel cleaning and preservation (per details)	Stainless steel	9258623 & -641 -652 9258629 -645 -654

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TABLE V-4 (Cont)

Finish No.	Type of Finish	Base Material	Part Number Ref
6.1.1.2	Surface treatment for zinc phosphate and chromate treatments, Specification MIL-T-12879 Type I, prepaint treatment Class 2, chromate	Zinc	9258653 9258655
6.1.2	Surface treatment for zinc phosphate and chromate treatments, Specification MIL-T-12879 Type II, chromate final finish	Zinc	9258626 9258628 9258640 9258644 9258646
7.3.1	Surface treatment for aluminum, chemical film, chromate, Specification MIL-C-5541 Class I, where subsequent paint finish is not required	Aluminum	9258607 9258609 9258611 9258616 9258649
9.1	Passivate and chromate	Brass	8797869 8797877 8797880

TABLE V-5

DEGREASING AND CLEANING EQUIPMENT

	Type	General Characteristics	Illustrative Example	Part Number Ref
1.	Vapor degreaser	Automatic vapor degreaser, with still and storage tank, conveyor for handling flat and rotating parts container baskets, complete with pump, pump motor, and conveyor drive motor and panel controls for automatic operation of still pump, and water cooling tower attachment, and for operation of conveyor from 5 stations	Barron-Blakeslee Model TH-LU or equal	9258607 9258611 9258616 9258620 9288623 9288624 9288631 9288632 9258642 9258651 8797869 8797879 8797880
2.	Liquid-vapor degreaser	Automatic degreaser, self-distilling, conveyorized, 3-tank type (boiling solvent, solvent rinse, vapor), for parts in rotary baskets, with solvent/water separator (water cooled), steam heat coils, exhaust hood, and cleanout doors. Automatic or manual operation of conveyor, complete with liquid level gauges and thermometers in each chamber, dual vapor controls, safety vapor control, and water control, including utility service connections.	Baron-Blakeslee Model TH-LL-V or equal	9258607 9258614 9258617 9258619 9258629 9258634 9258638 9258640 9258645 9258649 9258654

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TABLE V-5 (Cont)

Type	General Characteristics	Illustrative Example	Part Number Ref
3. Liquid-vapor vibratory degreaser	Vibratory liquid-vapor degreaser hopper-fed, with internal spiral elevator, counterflow solvent still, water separator, steam heated drying area, steam heating coil in solvent tank, for manual or automatic feeding of parts, complete with dual vibratory drive, motors, automatic controls and utility connections.	Detrex spiral conveyor Model or equal	9258609 8797878

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TABLE V-6

TUMBLING, DRYING, AND BLAST FINISHING EQUIPMENT

	Type	General Characteristics	Illustrative Example	Part Number Ref
1.	Tumbling machine	Barrel-type tumbling machine for metal parts deburring, 14-cu ft capacity, with unloading boot and drain door, 1.5-hp (min) drive motor, with variable-speed drive, complete with control, and dead-man brake	Almco-Queen Prods. Div., KST Co., Model DB-100 or equal	9258620 9258634 9258638 9258640 9258642
2.	Tumbling machine	Barrel-type, 4-compartment finishing machine, horizontal, 12-cu ft barrel capacity, 5-hp motor with variable speed drive, complete with controls	Roto-Finish Co. Model DW60-36-4 or equal	9258632 9258644 9258646 9258651
3.	Tumbling machine	Rotating counteraction, 2-drum, double-arm tumbling machine, variable-speed, 5-hp drive motor, with standard electric controls, timer, safety interlocks (fail safe), air supply (70 psi) connection for turret and drum brakes, and optional flow-through water hookup, and drain	Harper Buffing Machine Co., Harperizer Model 2-HA-12 or equal	9258645

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TABLE V-6 (Cont)

Type	General Characteristics	Illustrative Example	Part Number Ref
4. Spin dryer	Top-opening spin dryer, basket type, with dual 2000-watt heaters, 1-hp drive and standard electrical controls	Almco-Queen Prods. Div., KST Co. or equal	9258607 9258614 9258616 9258617 9258623 9258624 9258626 9258628
5. Drying machine	Rotating-drum metal parts dryer, steam heated, 4-rpm fixed speed, 4-hp drive motor, complete with controls	Metal Wash Machinery Co. or equal	9258644 9258646
6. Blast finisher	Barrel-type centrifugal blast, clean, and finishing machine, 2-cu ft work chamber, with horizontal endless belt, with dust control, timer, and control panel	Wheelabrator or equal	9258618
7. Deburrer	Special body plunger deburring machine	(Custom built) (DPD-8797877-T101) or equal	8797877

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TABLE V-7

PARTS/CHIPS SEPARATOR EQUIPMENT

	Type	General Description	Illustrative Example	Part Number Ref
1.	Separator	Stationary single-drum magnetic separator, with rubber-cleated belt running at 70 to 125-fpm over 12-in dia drum, with 1/4-hp motor, complete with electric controls	Rampe Mfg. Co. Model MS-12-A or equal	9258644 9258646
2.	Separator	Rotary screen parts separator with 2-ft dia x 4-ft long drum, inclinable (to 4-in/ft), with 1/4-hp drive motor and electric controls	Almco-Queen Prods. Div., KTS Co. Model R-2048 or equal	(various)
3.	Chip separator	Automatic chip separator, floor type with vibrator, feed unit, and flow control hopper with side delivery parts chute, 3-hp and 3/4-hp drive and blower motors, complete with electric controls	McKenzie Model L or equal	9258617 9258629 8797870 8797874 8797875 8797882
4.	Chip wringer	Chip wringer separator with fixed perforated outer basket and removable inner basket (40-in dia), 8.6-cu ft capacity, with 5-hp drive motor, complete with controls and accessory conveyor installation	Ametek Corp. Tolhurst Div. or equal	(all ASM parts)

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TABLE V-8

HEAT TREATMENT EQUIPMENT

	Type	General Characteristics	Illustrative Example	Part Number Ref
1.	Solution heat treatment furnace	Air furnace, fossil fuel or electrically-heated, with baffles to control air flow for uniform temperatures at set level throughout the treatment chamber, complete with automatic (burner or heating elements) controls (including one recording temperature sensor per zone), safety devices, and suitable doors for quick parts transfer to the quench tank		9258607
2.	Water quench tank	Cold water tank, in close proximity to HT furnace for minimum quench delay, water volume adequate for bulk of parts in containers that are to be quenched without exceeding bath temperature limits. Complete with utility connections, exhausts, and provisions for cleanout		9258607
3.	Aging oven	Air oven, fossil fuel, or electrically heated, with provisions to assure temperature uniformity at set level throughout treatment chamber, with automatic (burner or heating		9258607

TABLE V-8 (Cont)

	Type	General Characteristics	Illustrative Example	Part Number Ref
		element) controls (including temperature recorders) of selected treatment cycles, complete with safety provisions and utility connections.		
4.	Cure oven	10-drawer electric oven, 300 F ± 10 F, recirculating air flow, with ventilation provisions, complete electric controls with safety backup	Despatch Oven Model PLHD-10	9258631 9258632 9258634 9258638 9258640 9258641 9258642 9258649 9258651 9258652 9258653 9258655
5.	Vacuum sintering furnace	Vacuum furnace, controlled hydrogen atmosphere, electric elements (molybdenum), with heat shields and provisions for holding containers, nitrogen gas quenching with 3000 F capability, complete with electric controls, safety features, and molybdenum trays	C.I. Hayes, Inc.	9258634 9258638

TABLE V-8 (Cont)

Type	General Characteristics	Illustrative Example	Part Number Ref
6. Controlled-Atmosphere Annealing Furnace	Electric or fossil fuel heated furnace with cracked ammonia or similar atmosphere for bright annealing of brass, with automatic controls over heating and atmosphere conditions, indicating and recording temperature sensors, safety devices, and complete with utility connections in accordance with applicable codes		9258614

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TABLE V-9

SPECIALIZED DRILLING, BORING, & TAPPING EQUIPMENT

	Type	General Characteristics	Illustrative Example	Part Number Ref
1.	Special drilling machine	Special drilling machine with automatic part load/unload clamp/unclamp provision, filtered coolant system, chip removal aids, and complete electric, hydraulic, and pneumatic controls to process the fuze body: - Drill and counterbore 0.440 and 0.561-in dia - Recess 0.597 x 0.039-in feature - Drill four holes of 0.156-in dia - Deburr machined intersections	Modified Govro - Nelson Co. or equal	9258609
2.	Special multi-function machine	Rotary indexing dial machine, custom tooled and equipped to automatically drill, mill, ream, and tap selected features on the plunger body, featuring ten stations and 14 nests, complete with electric and pneumatic drives/actuators and controls	The Bodine Corporation Model 42-30 base (reference no. DPD-8797877-T14) or equal	8797877
3.	Special multi-function machine	Rotary indexing dial machine, custom tooled and equipped to automatically drill, ream, and deburr selected features on the plunger body, complete with electric and pneumatic drives/actuators and controls	The Bodine Corporation Model 42-30 base (reference no. DPD-8797877-T15) or equal	8797377

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TABLE V-9 (Cont)

	Type	General Characteristics	Illustrative Example	Part Number Ref
4.	Special drilling machine	Special purpose vertical dial machine, custom tooled, and equipped to automatically drill and ream selected features on the plunger body, complete with cooling system and electrical control panel	A.K.O. Corporation (reference no. DPD-8797877-T19) or equal	8797877